DOCTORATE IN CLINICAL PSYCHOLOGY

An exploration of relationships between greenspace, mindfulness, and perseverative thinking in relation to depression

Running header: GREENSPACE, MINDFULNESS, RUMINATION & DEPRESSION

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Dedication and Acknowledgements

This thesis is dedicated to Mwitumwa Ngenda, who lived with a compassionate and unrelenting fascination with the connections between internal and external worlds.

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Introductory Chapter

Clinical psychology and the location of depression

Clinical psychology and psychiatry traditionally conceptualise psychological distress as internal and individually located, and are criticised for neglecting the impact and aetiology of external human circumstances (Benning, 2015; Boyle, 1997; Pilgrim, 2011), such as relative deprivation and environmental factors (Cappeliez & Flynn, 1993). The British Psychological Society's (BPS) Division of Clinical Psychology (DCP) is addressing these criticisms with a general shift away from narrower biomedical, individualistic conceptualisations of distress within the person and toward a position of acknowledging the impact of adverse and traumatic experiences, including those of societal and systemic adversity (e.g. British Psychological Society [BPS], 2013; BPS, 2015; Johnstone, & Boyle, 2018).

Depression is a rapidly increasing global phenomenon and as such cannot be fully understood without its social contributors (WHO, 2017). While external and relational explanations are sometimes woven into psychological formulations for depression, the potential impact of absolute and relative deprivation and the residential environment remains more within the realm of psycho-ecological research (Hughes, 2017; Orford, 1994). While cognitive styles learned in response to adverse circumstances have been conceptualised as depressogenic thinking (e.g. Segal, Kennedy, Gemar, Hood, Pendersen, & Buis, 2006), psycho-ecological research is beginning to reveal relationships between the development, maintenance, and recurrence of depression and worldwide patterns of adversity, so increasingly, external circumstances may be thought of as depressogenic (e.g. Schwartz & Meyer, 2010).

Psychological Health Inequalities

Depressogenic circumstances may include any pervasive external stressor against which humans are relatively powerless, including absolute and relative deprivation (Beshai, Mishra, Meadows, Parmar, & Huang, 2017; Pelzer, Schaffrath & Vernaleken, 2014; Schwartz & Meyer, 2010) and adverse circumstances such as abuse that are predicted by deprivation and inequality (Easton, Kong, Gregas, Shen, & Shafer, 2017; Goff & Tottenham, 2015; Hayashi et al., 2015; Ouellet-Morin et al., 2015; Pereira, Negrão, Soares, & Mesman, 2015; Khalifeh, Hargreaves, Howard, & Birdthistle, 2013). Psychological inequalities are therefore those which adversely affect psychological wellbeing directly and indirectly, such as those which lead to depression. For example, inequalities such as poverty, debt, and unemployment may be conceptualised as personal or family level inequalities, as although they can affect whole neighbourhoods, they are also the direct conditions of an individual or family's life, including the experience of depression (e.g. Pelzer, Schaffrath & Vernaleken, 2014; Richardson, Elliott & Roberts, 2013).

Psychological inequalities also occur on an environmental level, wherein the neighbourhood milieu may be adversely affected by inequality on multiple levels, which are often predictive of depression. For example, living in an urban environment with high vehicular burden is predictive of traffic stress, which predicts depression (Song, Gee, Fan, & Takeuchi, 2007). The 'urbanicity effect', where living in densely populated and built urban environments adversely affects psychological wellbeing, has both support and contest in the research literature (Airaksinen et al., 2015). Specifically, the notion of a direct, causal urbanicity effect is contested, while factors such as individual and family level adversity or depressogenic cognitions may either interact with urbanicity, or may fully mediate relationship between urbanicity and depression (Jokela

et al., 2015; Kim, 2008; Kovess-Masfety, Lecoutour, & Delavelle, 2005; Paczkowski & Galea, 2010).

There is evidence to suggest that a lack of natural features in the residential environment such as areas including plant life (known as greenspace) is one such health and psychological inequality (Lee & Maheshwaran, 2011; White, Alcock, Wheeler, & Depledge, 2013). This may be of increasing importance in the prevention and reduction of depression as the global population urbanises (United Nations, 2007). Interaction with nature has also been demonstrated as beneficial to psychological wellbeing (Maller, Townsend, Pryor, Brown, & St Leger, 2006). Furthermore, restorative health environments have introduced contact with nature to aid recovery (e.g. Maller et al., 2006; Stigsdotter & Grahn, 2003).

Measurement of the dose of greenspace in an individual's environment, as well as measurement of their psychological suffering, is heterogeneous. For example, density of trees has negatively predicted prescription rates of antidepressants (Taylor, Wheeler, White, Economou, & Osborne, 2015), while residential proximity to parks has negatively predicted 'depressive symptoms' in adults (Reklaitiene et al., 2014). This provides some evidence of general residential greenspace having a potentially salutogenic impact on psychological wellbeing, although the nature of the relationship(s) between greenspace and depression is not well understood. For example, antidepressant prescription may not directly indicate levels of current depression experienced by a population (Taylor et al., 2015) and parkland may elucidate a different relationship with depressive features to aggregated greenspace (Bos, Wichers, Jeronimus, & van der Meulen, 2016; Reklaitiene et al., 2014).

Traditional theories and models of attention and distress

A range of theories have structured accounts of connections between the 'external' environment in terms of nature and landscape, and the 'internal' experience of cognition and emotion. The Biophilia hypothesis (Wilson, 1984) posits an evolutionary account of human affinity and orientation to nature, wherein those who engaged with nature harnessed it for survival, and furthered their genes. As industrial and technological global development leads to urbanisation, people become disconnected from nature and psychologically suffer (Kellert & Wilson, 1993; Wilson, 1984). Ulrich's (1983) Psychoevolutionary theory of stress reduction relates visual natural features of the landscape, (if deemed safe by the beholder), with cognitive and psychological stimulation that evokes pleasant affective experiences key to wellbeing.

Attention Restoration Theory (ART; Kaplan, 1995; Kaplan & Kaplan, 1989) is a theoretical integration of factors hypothesised to restore cognitive resources that deplete over time when under stress. The theory adds a cognitive, attentional element to evolutionary accounts that allows for examination of potential mechanisms linking the inner experience with the landscape. The key factor in ART is the natural environment, including greenspace, however, a willingness to be within a natural environment ('compatibility'); a sense of immersion in the environment (extent); a sense of escape from stressors or demands ('being away'), and a tranquil enough environment to allow for effortless attention ('soft fascination') are necessary components of attention restoration (Kaplan, 1995; Kaplan & Kaplan, 1989). ART conceptualises 'directed attention' as the psychological task of sustained cognitive effort in attending to the external environment or a task. Capacity for directed attention depletes as efforts are exhausted by the demands of contemporary life, including multiple sustained distractions, necessitating effortful attention. Attention is restored by immersively

viewing natural environments such as greenspace (Kaplan, 1995; Kaplan & Kaplan, 1989).

ART may provide a theoretical account of greenspace as preventative of depression and of relapse into depression. There is evidence in support of the relationship between greenspace and restoration of attention (Lee, Williams, Sargent, Williams, & Johnson, 2015). With regard to the requisite conditions of ART, soft fascination (undirected attention) may be key to restoration (e.g. Van Der Jagt, Craig, Brewer, & Pearson, 2017).

Mindfulness and Rumination

Rumination is a perseverative cognitive focus on adverse circumstances, including self-focused attention such as to low mood (Pössel, & Winkeljohn Black, 2017). It is a cognitive mechanism thought to underlie the relationship between stressors and depression which may be reduced by the mastery of attention via mindfulness (Pössel, & Winkeljohn Black, 2017; Radford et al., 2014; Svendsen, Kvernenes, Wiker, & Dundas, 2017). Mindfulness, as the dispassionate, non-judgemental focusing of attention, may reduce rumination, particularly for those who have experienced multiple episodes of depression (Radford et al., 2014). It is therefore possible that mindfulness could reduce depression or prevent relapse via reductions in rumination (Petrocchi & Ottaviani, 2016; Radford et al., 2014).

Facets of mindfulness may be studied as dispositional traits which may exist to varying extents in people who have not received mindfulness training and those who do not practice mindfulness (Baer, et al., 2006; Baer et al., 2008). These include attentional cognitive processes of *observing*, *describing*, and *acting with awareness*, as well as *non-judging of inner experience*, and *non-reactivity to inner experience* (Baer et al., 2008).

As rumination can include self-focussed attention and judging of inner experience, and reactivity to inner experience of low mood to depressogenic effect, mindfulness facets of *non-judgement* and *non-reactivity* may be inversely related to rumination and depression (Petrocchi & Ottaviani, 2016). The dispassionate and flexible aspects of attentional facets of mindfulness may also be thought of as inverse to the rigid perseveration of rumination (e.g. Svendsen et al., 2017).

In summary, rumination and mindfulness are inversely related to one another, while mindfulness predicts reduction in depression via less rumination (Svendsen et al., 2017). Adverse environmental conditions are predictive of depression via cognitive mechanisms such as rumination, while some facets of mindfulness may be protective (Pössel, & Winkeljohn Black, 2017; Segal et al., 2006; Svendsen et al., 2017). Greenspace may be protective against depression, while a lack of greenspace may predict it (White et al., 2013).

The thesis overview

This thesis constitutes an exploration of the relationships between residential greenspace and socioeconomic deprivation, depression, rumination, and facets of mindfulness. Two chapters report an overall exploration of the evidence for the nature of relationships between internal (namely rumination and dispositional mindfulness) and external factors (residential greenspace and socioeconomic deprivation) associated with depression.

Chapter one comprises a systematic review of empirical literature related to depression and residential greenspace. It highlights a growing body of evidence for a negative relationship between residential greenspace and depression. However, mechanisms underlying this relationship are not conclusively drawn. Whilst ART

(Kaplan, 1995; Kaplan & Kaplan, 1989) provides a theoretical basis for the search for research investigating residential greenspace and rumination, the existence or nonexistence of this relationship remains unknown.

Chapter two presents an empirical study, constituting a cross-sectional investigation of relationships between 'external' factors (environmental measures of greenspace and socioeconomic deprivation,) and 'internal' factors (rumination, mindfulness), and past history of episodes of depression. Adult participants across England and Wales completed an online survey including psychological measures of the 'internal' factors, and self-reported how many times they had experienced depression. Their postcodes allowed investigation into 'external' factors of environmental deprivation and residential greenspace. In order to provide a more contemporary indication of greenspace than existing databases that was consistent across England and Wales, residential greenspace was calculated specifically for the project by Mersey Forest's Geographic Information Systems (GIS) coordinator, a collaborator of the research. Rumination and number of previous depressive episodes were positively associated, and rumination was strongly negatively predicted by the '*non-judgement of inner experience*' facet of mindfulness. Moderation analysis revealed that urban parkland density within a 3km radius of postcode negatively predicted rumination for people living in the most deprived areas.

The survey was jointly advertised with another study in order to reduce participant burden, where data were shared between the author and another researcher who investigated stress in those who both had and had not experienced depression. The projects were distinct and the author carried out a significant proportion of the recruitment, conducted the data collection for the study and analysed the results presented in the empirical chapter independently of the other researcher.

Systematic review of psycho-ecological literature revealed some evidence of residential greenspace predicting current depression, but did not uncover any findings regarding residential greenspace and ruminative cognition. The empirical study then suggests that there may be conditional associations between neighbourhood urban parkland and ruminative cognitive style.

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Chapter 1: Literature Review

The relationship between environmental greenspace and depression in adults: A systematic review and narrative synthesis

9536 words

Article prepared for submission to the open-access journal *'SAGE Open'* for peer review (10,000 word limit). Please see Appendix A for a copy of journal guidelines for authors.

Abstract

Background: Ecological factors contribute to depression as a growing global problem. Recently, research is beginning to focus on relationships between greenspace and depression. **Objectives:** To investigate relationships between greenspace and depression including duration, relapse and rumination. **Data sources:** CORDIS, MEDLINE, PsycINFO, Science Direct, Scopus, and SSCI. **Study eligibility criteria:** Peer-reviewed, non-experimental quantitative research available in English with adult participants, using reliable depression measurement, measuring outdoor greenspace. **Synthesis:** Results regarding the relationship between depression and greenspace from included studies were narratively synthesised. **Results**: Eleven studies published between 2007 to 2017 were identified: ten cross-sectional and one cohort. Evidence suggested a negative predictive relationship between higher density residential greenspace and depression. **Limitations:** No evidence was found regarding duration, relapse, rumination and greenspace. **Conclusions:** Greenspace may negatively predict risk and prevalence of depression, particularly trees and parklands in urban areas. **Implications:** Further research into mechanisms underlying and influencing this relationship is required. **Registration number:** CRD42016047315

Keywords

Depression

Greenspace

Health Inequalities

Systematic Review

Introduction

Rationale: Depression

The World Health Organization (WHO) defines depression as a 'common mental disorder', in which persistent sadness and loss of interest or pleasure in activities may be accompanied by changes in appetite or sleep, loss of energy, anxiety, restlessness, reduction in concentration, feelings of worthlessness, guilt, or hopelessness, and thoughts or behaviours of self-harm and suicide (WHO, 2017). Depression is a major contributor to the global burden of disease, experienced by over 300 million people worldwide, and incidence is rising (WHO, 2017). The impact of depression is both serious in its disabling and life-limiting capacity, and vast in terms of prevalence and relapse. Understanding the contributing factors to the development and maintenance of depression is therefore a key aim of researchers across a range of disciplines, for the development of effective interventions to prevent its occurrence, maintenance, and recurrence.

Diagnostic manuals such as the Diagnostic and Statistical Manual of Mental Disorders (DSM-V: American Psychiatric Association, 2013), and the International Statistical Classification of Diseases and Related Health Problems (ICD-10: WHO, 1992) define depression as a disorder via symptomatology. They list combinations of symptoms and degrees of severity affecting functioning as distinct disorders, which are variants of depressive disorders. For example, in the DSM-V major depressive disorder and persistent depressive disorder are largely differentially diagnosed via longevity. A traditional psychiatric understanding of depression is one of a medical condition, caused by biochemical imbalances, which are caused wholly or in significant part by genetic factors, and may in turn cause epigenetic differences (Andrews, Bharwani, Lee, Fox, & Thomson, 2015; Neumeister, Young, & Stastny, 2004).

Medical conceptualisations of depression are widely criticised as poorly evidenced etiological models, despite their increasing complexity and detail (Healy, 2015; Leventhal & Antonuccio, 2009). Moreover, medical explanations are criticised for their focus on depression as emerging and existing inherently within the individual, with little acknowledgement of, for example, experiential, relational, systemic, socioeconomic, and ecological factors (Pilgrim, 2011). Advocates of the 'biopsychosocial' model argue that it provides explanations of interactions between underlying biological, psychological and social factors (Garcia-Toro & Aguirre, 2007). Critics of this model, however, argue that the explanatory focus remains on the biological, with less investigation of the psychological and less still of the social factors (British Psychological Society [BPS], 2013; Moncrieff & Crawford, 2001; Pilgrim, 2011; Smail, 1993).

Conversely, psychological explanations of depression traditionally focus on cognitive styles as causal and maintaining factors, thought to be largely caused by the experiences of the individual (e.g. Beck, 1976; Nolen-Hoeksema, Girgus & Seligman, 1992). Theoretically, formative experiences such as prenatal maternal depression (Kinsella & Monk, 2009), attachment (Ainsworth, 1973; Bowlby, 1969) and social learning (Bandura, 1977) inform cognitive tendencies (Beck, 1976; Nolen-Hoeksema et al., 1992), in interaction with altering the regulation of emotion and behaviour (Malik, Wells, & Wittkowski, 2015) resulting in the onset of patterns of serious psychological distress such as depression.

Relational, systemic, and socioeconomic factors can also be key to psychological formulation, which seeks to both describe and explain depression (Hughes, 2017; Orford, 1994). However, criticism of individualistic conceptualisations of depression is not limited to medical accounts and the biopsychosocial model. Psychological theories,

models, and praxis are subject to similar criticism (Benning, 2015; Boyle, 1997). The integration of internal (e.g. cognitive and behavioural) and external (e.g. systemic and environmental) explanations of depression may therefore be a necessary direction for comprehensive depression research to guide the plethora of developing interventions.

Internal factors associated with depression.

Cognitive mechanisms such as negative inferences and hopelessness in response to experiences (The Hopelessness Model: Abramson, Alloy & Metalsky, 1989); and ruminative responses to depressed mood (Response Style Theory: Nolen-Hoeksema et al., 1992) have been found to predict the onset and maintenance of depression (Abramson, Alloy, Hankin, Haeffel, MacCoon, & Gibb, 2002; Treynor, Gonzalez, & Nolen-Hoesksema, 2003). These models have been integrated, as interactions between these cognitive responses to internal and external experiences and depression have been evidenced (Pössel, & Winkeljohn Black, 2017). For example, rumination predicts hopelessness (Lavender & Watkins, 2004) and mediates the relationship between negative inferences and future depression (Spasojevic´& Alloy, 2001). Moreover, rumination has been found to predict depression independently of emotion regulation strategies and factors such as self-esteem and optimism, as well as having a deleterious impact on the relationship between stress and depression (Zawadzki, 2015). Individual negative inferences include beliefs that adverse events have stable consequences, global conclusions, and negative implications about oneself. These negative inferences predict rumination, which interacts with individual inferences to predict depression (Pössel, & Winkeljohn Black, 2017).

The interactive nature of rumination, hopelessness, and internally-focused cognitions can be conceptualised as depressogenic thinking, which becomes associated with low mood. This cognitive style is re-activated when low mood is re-experienced,

catalysing relapse (Segal, Kennedy, Gemar, Hood, Pendersen, & Buis, 2006). While depressogenic thinking has a strong predictive relationship with depression recurrence, behavioural factors such as decreased activity and smoking have also been found to have a bidirectional relationship with depression (e.g. Fluharty, Taylor, Grabski, & Munafò, 2017; Ormel, de Jonge, & Stavrakakis, 2012) and with cognitive mechanisms of depression such as rumination (Clancy, Prestwich, Caperon, & O'Connor, 2016). The cognitive and the behavioural can therefore be regarded together as the internally focused psychological account of depression. Furthermore, as depressogenic thinking and behaviour exacerbate one another and are learned via adaptation to adverse events, differences in objective adversity should predict internal depression experiences, and be conceptualised as the external factors of depression with no less salience than internal factors (e.g. Clancy, et al., 2016; Kuo & Chiang, 2013).

External factors associated with depression.

Systemic factors are well established as strong predictors of depression, despite a relative dearth of their integration in psychological models (Newnes, 2014). As external factors associated with depression, systemic factors may be defined as influences on depression from societal structures. On a family system level, adversity experienced during childhood such as parental separation (Sands, Thompson, & Gaysina, 2017), parental loss (Berg, Rostila, & Hjern, 2016), and abuse (Infurna, Reichl, Parzer, Schimmenti, Bifulco, & Kaess, 2016) predict depression in adulthood. While these experiences can be viewed purely developmentally, for example in terms of Attachment theory (Ainsworth, 1973; Bowlby, 1969), they may also be viewed in terms of wider socioeconomic systems of inequality that contribute to and exacerbate depressogenic formative experiences (Dressler, Oths & Gravlee, 2005; Horwitz, 1999; Schwartz & Meyer, 2010).

The social stress paradigm indicates socioeconomic stressors as interactive contributors to depression, where inequality interacts with ‘stress’, which can include the internal predictors of depression and further adverse experiences to which inequality may contribute, exacerbate, or add (Schwartz & Meyer, 2010). Multiple factors linked with wider socioeconomic inequality in adult life predict depression, such as financial debt (Richardson, Elliott & Roberts, 2013), unemployment (Pelzer, Schaffrath & Vernaleken, 2014), and adverse working conditions (Theorell et al., 2015). Furthermore, stable systemic factors such as belonging to a marginalised group predict internal depression factors, for example via gender (Alibrahim, Al-Sadat & Elawad, 2010), race (Barnes, & Bates, 2017), or sexual identity (Ploederl & Tremblay, 2015).

Socioeconomic deprivation predicts depression across a wide range of domains (e.g. income, education, housing) at both absolute and relative levels (Beshai, Mishra, Meadows, Parmar, & Huang, 2017; Kuo & Chiang, 2013). The physical living environment is an indicator of socioeconomic deprivation and health inequality. As the physical environment has been increasingly linked to health and wellbeing, epidemiological researchers are also beginning to examine the environment as a potential factor underlying depression (Lee & Maheswaran, 2011). Psychological distress has been related to both perception of residential environment, and environmental factors independent of perception, i.e. ‘neighbourhood effects’ (Gong, Palmer, Gallacher, Marsden, & Fone, 2016). Researchers must therefore seek to understand depression and depressogenic thinking and behaviour in relation to depressogenic social and environmental factors.

Physical aspects of residential environments become ever more salient as indicators of health inequalities, as the worldwide population becomes both increasingly urbanised (United Nations, 2007) and increasingly depressed (WHO, 2017). As people

of lower socioeconomic status are more likely to live in highly urbanised environments with little access to nature, the relationship between environmental factors and depression must be examined while taking socioeconomic inequalities such as income into account. Natural environments whose primary feature is plant-based life, known as 'greenspace', are particularly scarce for the populations most vulnerable to depression via other external factors (e.g. Heckert, 2013). This inequality for those vulnerable to depression is exacerbated by the possibility that the presence of greenspace may be a protective factor against depression, and its absence may be related to increased incidence, independent of other socioeconomic inequality (e.g. Taylor, Wheeler, White, Economou, & Osborne, 2015).

Rationale: Greenspace

Greenspace as restorative.

Attention Restoration Theory (ART; Kaplan, 1995; Kaplan & Kaplan, 1989) presents the human experience of being in an environment rich in natural features, such as greenspace, as having a potentially restorative effect on cognitive capacity. As humans in urbanised societies divide their attention between multiple tasks and responsibilities and the chaotic urban milieu, ART predicts that 'directed attention' becomes depleted, resulting in 'attention fatigue' (Kaplan, 1995; Kaplan & Berman, 2010). Attention fatigue inhibits the ability to problem-solve, regulate emotion, and intentionally focus on adaptive thoughts and experiences (Kaplan, 1995). Attention fatigue has been theoretically linked with several cognitive mechanisms thought to underlie depression, such as rumination (e.g. Ursin, 2005).

The proposed mechanisms by which greenspace may be restorative (and a lack thereof may be related to adverse psychological consequences of attention fatigue) are cognitive (Kaplan, 1995). Greenspace would theoretically restore depleted attention

capacity by catalysing and allowing a cognitive experience of effortless rather than directed attention, although in order for attention restoration to occur, the environment would need to satisfy four criteria. The four criteria are: ‘extent’, in which there is a sense of immersion in the environment; ‘being away’, in which the moments spent attending to the environment provide an escape from activities that demand directed attention; ‘soft fascination’, in which attention rests on the natural environment in an effortless, rewarding way; and ‘compatibility’, in which exposure to the natural environment is desirable or acceptable to the person (Kaplan, 1995).

There is evidence in support of ART’s proposed restorative cognitive relationship between greenspace and psychological wellbeing, to include that greenspace in psychological interventions may be advantageous (Bratman, Daily, Levy, & Gross, 2015; Dinno, 2007). For example, walking and running in natural environments may be more beneficial to physiological and emotional measures of wellbeing than the same activities in ‘synthetic environments’, such as indoor or outdoor environments without greenspace (Knight, Buyung-ali, Bowler, & Pullin, 2010). Moreover, residential greenspace has been found to be beneficial to physical and mental wellbeing even where those with higher densities of residential greenspace do not engage in any more physical activity than those with little greenspace (Groenewegen, van den Berg, Maas, Verheij, & de Vries, 2012).

The often-cited ART hypothesis that attention and thus the ability to control the focus of attention is restored by safe, immersive, ‘calm enough’ natural environments has been scrutinised via meta-analysis of its evidence base (e.g. Ohly et al, 2016). For example, Ohly and colleagues (2016) found some evidence in support of exposure to natural environments aiding short-term memory and reasoning in three meta analyses, however, did not find high quality support in the further ten meta-analyses conducted.

The authors concluded that, although there is support for exposure to nature, the specific cognitive benefits of exposure to nature are unclear and therefore the process from nature exposure to attention restoration is unknown. Furthermore, there has been suggestion that ART and the focus of its evidence base on the cognitive aspects of attention restoration neglects potential affective processes which may underlie the connection between exposure to natural environments and results that suggest that capacity for attention has been restored (e.g. Stevens, 2014). Stevens (2014) found that priming for negative affect resulted in participants rating natural environments as more restorative than urban in the categories of 'fascination' and 'being away'. Stevens argued that as 'fascination' was the only condition with an interaction effect whereby negative priming resulted in a higher mean 'restoration' rating, that it may be an overlooked affective mechanism of restoration.

Residential greenspace and depression.

Residential greenspace may be one aspect of social inequality among many that may have a relationship with the development, repetition, or maintenance of depression. Living in a highly urbanised environment with little greenspace requires sustained directed attention without the opportunity for attention restoration that natural environments afford (e.g. Kaplan & Berman, 2010). This may result in attention fatigue, leaving individuals and the systems they create vulnerable to cognitive and affective difficulties that may underlie depression. Indeed, general psychological distress has been found to reduce, while wellbeing increases, for individuals following moving home to an area with greater greenspace density (White, Alcock, Wheeler, & Depledge, 2013). While there is a clear socioecological link between residential greenspace density and other environmental and systemic socioeconomic inequalities (e.g. Lachowycz & Jones, 2014), some studies have revealed independence of a lack of residential greenspace as a

predictor of psychological distress (White et al., 2013). However, the existence and nature of a relationship between greenspace and depression has yet to be clearly established.

Aims and Objectives

The aims of the current review were to investigate the relationship between depression and residential greenspace in adult participants via narrative synthesis of all available research literature reporting relationships between residential greenspace and depression since 1995. Residential greenspace was of interest as a potential environmental influence on depression as Kaplan's (1995) ART suggested restoration via mechanisms that may link nature with cognitive precursors to depression such as rumination (Kaplan, 1995; Ursin, 2005).

As the review focused on evidence for or against the existence of the relationship between greenspace and depression as a preliminary question to be answered in this field, correlational studies were included while intervention studies seeking causal conclusions were excluded. Comparisons between densities of greenspace in urban areas, and levels of greenspace within different residential proximities were of interest.

Outcomes regarding depression as predicted by residential greenspace were of interest, as were those contextualising the strength of this relationship with respect to demographic factors and the nature of the greenspace. The review aimed to examine and narratively synthesise the quality and implications of the available evidence, and to consider further research in light of the evidence reviewed.

Research Questions

The purpose of the systematic review was to answer the following research questions via narrative synthesis of research findings:

1. To what extent is greenspace predictive of adult depression?
2. Is there a reported difference in prevalence, duration, or recovery from depression in adults in urban environments with high and low levels of green space?
3. To what extent is residential green space predictive of adult ruminative and perseverative thinking?

Method

Protocol and Registration

A systematic review of research literature examining evidence of a relationship between environmental green space and depression in adults is narratively synthesised herein. The Preferred Method for Reporting Systematic Reviews and Meta Analyses (PRISMA; Moher, Liberati, Tetzlaff, & Altman, 2009) statement and checklist provided the framework for completion of this review, in accordance with the PRISMA Explanation and Elaboration Document (Liberati, Altman, Tetzlaff, Mulrow, Gøtzsche et el, 2009; for protocol see Appendix B). The review was registered at the University of York's PROSPERO website (available from http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42016047315). Figure 1 illustrates the searching and screening process as a PRISMA flowchart.

Eligibility Criteria

Inclusion criteria.

Published, peer-reviewed studies reporting results that address the relationship between residential greenspace and depression, available in English, using adult participants were included. Case-control, prospective, and cross-sectional, correlational designs were included. Research using a mixed methods design including both qualitative and quantitative data was to be included where quantitative data were identifiable and met all other inclusion criteria. Research using at least one environmental measure of residential greenspace and at least one measure of depression, rumination, or perseverative thinking was included.

Exclusion criteria.

Studies of non-humans, children and adolescents aged 17 years or younger were excluded. Studies involving pseudo-green space as an alternative to actual green space, for example, virtual reality, were excluded. Studies involving indoor greenery such as plants in office spaces were excluded, as were studies of mortality, physical health conditions and exercise. Exclusively qualitative research, Randomised Controlled Trials (RCTs), experimental designs and intervention studies, reviews, and meta analyses were excluded. The decision was taken to exclude RCTs, experiments and interventions due to the focus on real, environmental greenspace proximal to residence, as opposed to shorter term exposures to e.g. nature walks as interventions designed with a mental or physical health goal in mind, or studies of nature-based psychological therapies for depression. Specific interactions with natural or simulated greenspace were not variables of interest, rather, the assumption within ART that natural environments can be restorative was of interest within a residential context, and the review sought to gain a wider view of cross-sectional evidence of any relationship between depression and residential greenspace.

Studies of general mental health without examining depression, or without at least one validated measure of depression, rumination, or perseverative thinking were excluded.

Information Sources

Following scoping searches, six electronic databases were selected for their relevance to psychology and greenspace, comprising: CORDIS; MEDLINE; PsycINFO; Science Direct; Scopus; Social Sciences Citation Index. The primary researcher searched from 1995 onwards (October 2016), due to Kaplan's key research into the psychologically restorative potential of nature (Kaplan, 1995). This process was repeated during April 2017, for publications between October 2016 and April 2017, due to the recently burgeoning nature of mental health ecology and eco-psychology research. The reference lists of studies included at the final screening stage were also searched for relevant literature, which the primary and secondary researchers examined with regard to the eligibility criteria.

Search

Following several drafts of piloted search terms and consultation with experts, a final search term framework was applied to each database, and adapted only to comply with search functions between different databases (for exemplar search see Appendix C). The terms were: ('depress*' OR 'recurrent depress*' OR 'perseverat*' OR 'ruminat*') AND ('greenspace*' OR 'green space*' OR 'green-space' OR 'park' OR 'parkland' OR 'parks' OR 'wood*' OR 'forest*').

Study Selection

A primary researcher conducted scoping searches, established that no other review of the relationship between depression and residential green space had been registered, and

registered the proposed review on the University of York's PROSPERO website. Scoping searches and discussion with experts established appropriate search terms and databases for data collection. In October 2016, the primary researcher searched each database and downloaded all records to folders for each corresponding database within a Mendeley library. The primary researcher then collated all records into one folder, and created a further folder for all records with duplicates removed. Research papers with titles on subjects irrelevant to the research question were excluded.

A second researcher examined the remaining titles and discussed ambiguous titles with the primary researcher, all of which were included at this stage. The primary researcher then examined the abstracts and excluded papers until the final 25 papers, which required full text screening by both primary and secondary researchers, with full agreement. Final included studies provided reference lists for further searching. During the second search process, the second researcher also examined a random sample of 20% titles and abstracts (k=69 records) with full agreement on inclusion and exclusion decisions. Both primary and secondary researchers agreed fully regarding inclusion and exclusion decisions for the final records at full text review.

Data Collection Process

The primary researcher was able to obtain sufficient data from the final included reports to determine how both greenspace and depression were measured, the methodology and analysis used for those data, and the main findings of the studies. The second researcher cross-checked the data extracted (see Table 1) with printed copies of the included reports and was in agreement with data included. There were sufficient data for quality analysis included in each report, therefore contacting authors was not necessary.

Data Items

Data were sought from each record regarding: participants' demographics; country and setting, which was salient due to the environmental nature of greenspace research; detail of greenspace and depression measurement; methodology; analysis; main findings; and information for quality assessment regarding risk of bias and quality of reporting, such as sources of funding, sample size, and discussion of limitations and generalisability.

Quality Assessment: Risk of Bias in Individual Studies

A combination of the Newcastle-Ottawa Scales for cohort studies (NOS; Wells et al., 2012; Appendix D) cross-sectional studies (Herzog et al., 2013; Appendix E), and the Strengthening the Reporting of Observational studies in Epidemiology checklist (STROBE; von Elm et al., 2008; Appendix F) provided an overview of the relative quality of final included studies. Both the NOS and the STROBE focus on quantitative research, providing a guide to assess the quality of cohort, cross-sectional, and epidemiological research.

Risk of methodological bias was assessed via the NOS. Cohort and cross-sectional studies were assessed with the original and cross-sectional adaptations of the NOS, respectively. Both versions of the NOS utilise a star-rating system to quality assess facets of research methodology. Each included paper was scrutinised using the appropriate version of the NOS and results tabulated (see Appendix G).

Risk of reporting bias in individual studies was assessed via the STROBE. The STROBE uses a 22-item yes/no/not applicable checklist to quality assess aspects of reporting the research. For the purpose of this review, one possible 'star' represents the presence of the desirable quality per specific item (including sub-items this results in 26 possible 'stars'), allowing for an overall quality star-rating for each study including both

the NOS and the STROBE. Both methodology score and reporting scores are also included. Cohort study methodology scores (NOS) are of a possible nine stars and cross-sectional methodology scores are of a possible ten stars. This resulted in a maximum total quality score of 35 for the cohort study and 36 for the cross-sectional studies.

If any studies were of especially low methodological quality to the extent that both reviewers agreed the resulting data would be too unreliable to be meaningfully reported, or if reporting quality was so low that methodological quality and risk of bias would be in doubt, the studies would be excluded. In the narrative synthesis of results across studies, results from higher quality studies would be acknowledged to be more influential than e.g. studies with lower relative quality as measured by the NOS and STROBE with conflicting results.

Summary Measures

The principle summary measures were the influence of each predictor (particularly greenspace) on the primary outcome variable of depression via multiple regression analyses (ß) and probability values and odds ratios where logistic regression was used.

Synthesis of Results

Following collection of records that met criteria and quality assessment, findings relevant to the objectives of the review were narratively synthesised in answer to the research questions. A meta-analysis was not feasible due to the range of methods of variable and outcome assessment.

Risk of Bias Across Studies

Risk of selective reporting bias within studies was assessed via the STROBE, however, a general risk of publication bias across studies exists, as all were selected from peer reviewed academic journals, which requires consideration and acknowledgement within synthesis of results.

Results

Study Selection

Initial searching (Time 1[T1]: 1995 to October 2016) returned 1811 records, reduced to 1767 following removal of duplicates. During full-text screening, 17 records were excluded on the basis of non-separate analysis for children and adults, and insufficient measurement of greenspace or depression, resulting in seven papers. The primary reviewer consulted with two other reviewers regarding inclusion of a study where greenspace was measured via self-report, resulting in the decision to exclude the paper. The primary reviewer screened the references included in final papers, resulting in inclusion of a further study (Miles, et al., 2011), which the second reviewer corroborated. This resulted in eight included studies.

When the search was repeated (Time 2 [T2]: October 2016 to April 2017) a further 344 records returned upon initial searching, reduced to 343 following duplicate removal. The second reviewer examined a random selection of 20% (k=69) titles and abstracts, resulting in full concordance with the primary reviewer's decisions. Seventeen full text records were included for full-text assessment. Six records were excluded due to interventional or experimental design, five for non-specific or insufficient depression measurement, and three for insufficient measurement of greenspace. The repeated search

resulted in three further studies for inclusion, totalling 11 final studies included for review (see flow diagram Figure 1).

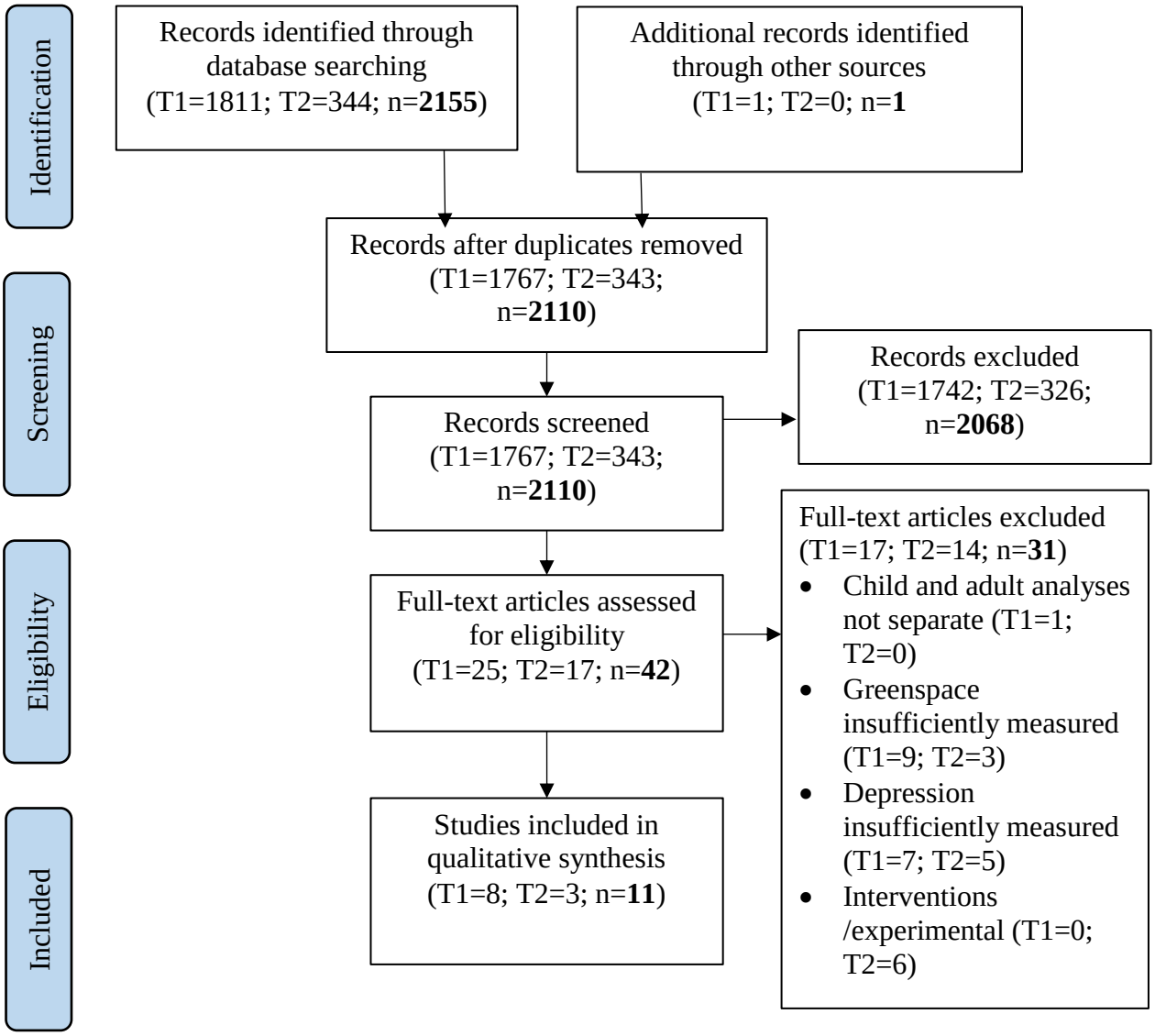

Figure 1: PRISMA diagram of search and screen process

Study Characteristics

Study characteristics are summarised in Table 1. All studies measured depression, but none measured recovery from depression, remission, rumination or perseverative thinking specifically. All but one study (Picavet et al.) were cross-sectional, with the Picavet study adopting a retrospective cohort design. Studies were published from 2007

to 2017. Five studies were conducted in the USA, two in the UK, two in the Netherlands, the remaining two were conducted in Lithuania, and Korea. Sample size ranged from 1023 to 169,026 participants. All but three studies (Cohen-Cline, et al., 2015; Cox, et al., 2017; Reklaitiene, et al., 2014) used secondary data, and the studies that used primary data used existing registries as part of wider projects.

Five studies investigated relationships between greenspace and various health domains (Akpinar, Barbosa-Leiker, & Brooks, 2016; Cox, et al., 2017; Picavet, et al., 2016; Reklaitiene, et al., 2014; Song, et al., 2007); three investigated the relationship between greenspace and various mental health domains (Beyer, et al., 2014; Bos, et al., 2016; Cohen-Cline, Turkheimer, & Duncan, 2015), and three investigated greenspace and depression specifically (McEachan, et al., 2015; Miles, Coutts, & Mohamadi, 2011; Min, et al., 2017). Cohen-Cline, and colleagues (2015) focused on twins, while McEachan and colleagues (2015) focused on pregnant females. The remaining nine studies primarily focused on the relationship between greenspace and their outcome variables. Other primary outcomes were factors such as traffic stress (Song, et al., 2007), suicidality and suicide attempts (Min, et al., 2017), and physical activity (Picavet, et al., 2016) and aspects of the environment, such as urban populations (Miles, et al., 2011; Reklaitiene, et al., 2014).

Table 1: Study Characteristics

Study	Participants, Area/ country	Greenspace measure	Depression/ Rumination Measure	Methodology	Analysis	Main Findings	Method Quality Score (NOS max=9)[a]	Reporting Quality Score (STROBE max=26)[b]	Total Quality Score (max=35)
Akpinar, et al., (2016)	Adults aged 18-75+ N=5148 98 zip-codes across Washington State, USA	National Land Cover Data (NLCD)[c] measure used to derive one aggregated % green space value and 'types' of green space within post codes	Behavioural Risk Factor Surveillance System (BRFSS)[d] telephone interview anxiety-depression complaints (8 items)	Cross-sectional	Multilevel linear regression	No association between aggregated greenspace or type of greenspace and depression.	7	19	26
Beyer, et al.. (2014)	Adults aged 21-74 N=2479 in 229 census block groups Wisconsin, USA	Normalized Difference Vegetation Index (NDVI)[e] % tree canopy coverage of area	Depression Anxiety and Stress Scales (DASS-42)[f]	Cross-sectional	Median tree canopy coverage was 10%, bivariate analysis of <10% and 10%≤. Multivariate linear regression.	Higher levels of tree canopy ß=1.005 (0.293) $p<0.01$, and higher levels of greenspace ß=1.369 (0.464) $p<0.01$ predicted lower levels of depression. Combined greenspace and tree canopy predicted lower depression ß=1.379 (0.397) $p<0.01$.	9	21	30
Bos, et al., (2016)	Adults aged 18-87 N=4924 The Netherlands	Dutch National Land Cover Classification Database (BB)[g]	DASS-42	Cross-sectional	Censored regression to account for skew; mediation; moderation	Higher levels of greenspace within a 3km radius were associated with lower depression ß = -16.9 (8.1) $p<0.05$.	9	21	30

Study	Participants, Area/ country	Greenspace measure	Depression/ Rumination Measure	Methodology	Analysis	Main Findings	Method Quality Score (NOS max=9)[a]	Reporting Quality Score (STROBE max=26)[b]	Total Quality Score (max=35)
						This was moderated by age and gender.			
Cohen-Cline, et al., (2015)	Adult twin pairs, (age range not reported)- mean male age =38.7(SD 16.4) mean female age=39.7(SD 17.1) N=4338 Mostly Washington State, USA	NDVI	Modified, 2-item Patient Health questionnaire (PHQ-2)[h]	Cross-sectional twin study	Multiple regression, multilevel random intercept model took account of within and between twin pairs	Within monozygotic twins, the twin with higher levels of green space had a lower risk of depression ß=0.44 (0.74—0.14) $p<0.05$.	8	18	26
Cox, et al., (2017)	Adults (full age ranges not given) N=474 included for greenspace variable Milton Keynes Luton, and Bedford, England	NDVI	DASS-21[i]	Cross-sectional	Generalised linear regression modelling	Depression was negatively associated with areas of more greenspace ß= - 0.04 $p<0.05$.	8	19	27

Study	Participants, Area/ country	Greenspace measure	Depression/ Rumination Measure	Methodology	Analysis	Main Findings	Method Quality Score (NOS max=9)[a]	Reporting Quality Score (STROBE max=26)[b]	Total Quality Score (max=35)
McEachan, et al., (2015)	Pregnant females full age range not given (<21->35) N=7547 Bradford, England	NDVI map, and quintiles of relative greenness density (1=least green, NDVI=0.28 to 5=greenest, NDVI=0.60)	'Severe depression' subscale of the GHQ-28[j]	Cross-sectional	Logistic regression	Pregnant females in greener quintiles were significantly less likely to experience 'depressive symptoms' compared with least green at NDVI 100m ß=0.82 (0.69-0.98) $p<0.05$ and NDVI 500m ß=0.81 (0.67-0.98) $p<0.05$.	9	24	32
Miles, et al., (2011)	Adults, (age range not reported) N=1944 Miami, Florida, USA	Number of acres of greenspace per census tract. Categorical variable (1=no greenspace; 2=between 0 and 80th percentile; 3=between 80th and 100th percentile)	Center for Epidemiologic Studies Depression scale (CES-D)[k]	Cross-sectional	Ordinary least squares (OLS) regression	Those living in areas with some greenspace had fewer depressive symptoms than those living in areas with no greenspace ß=0.299 $p<0.01$, but those living in areas with the highest density of greenspace did not display fewer depressive symptoms.	6	19	25
Min, et al., (2017)	Adults aged 20- ≥60 (upper age range not given)	Parks and green areas (m^2) per capita; divided into quartiles for analysis	CES-D	Cross-sectional	Logistic regression	Depressive symptom prevalence was lowest in the greenest quartile (13% greater odds of depression in least	7	21	28

Study	Participants, Area/ country	Greenspace measure	Depression/ Rumination Measure	Methodology	Analysis	Main Findings	Method Quality Score (NOS max=9)[a]	Reporting Quality Score (STROBE max=26)[b]	Total Quality Score (max=35)
	N=169026 for 'depressive symptoms' Across Korea					green compared with greenest quartile).			
Picavet, et al., (2016)	Adults, aged 20-59 at baseline N=4005 Doetinchem, The Netherlands	BB	20 items from the CES-D used in round 5 only	Retrospective Cohort	Multiple regression	More total greenspace was associated with lower depression ß=-0.27 (-0.42 - -0.11) $p<0.05$, but more urban greenspace was not.	5	19	24
Reklaitiene, et al., (2014)	Adults aged 45-72 N=6944 Kaunas city, Lithuania	Residence proximity to nearest city park larger than 1 hectare with 65% greenspace land cover according to spatial land cover datasets	CES-D10	Cross-sectional	Multiple logistic regression	In females who used a park ≥4h/week higher residential distance was associated with higher risk of depressive symptoms at 300m-999m OR=1.56 (1.09-2.33) $p<0.01$ and at ≥1km OR=1.92 (1.11-3.3) $p<0.05$.	8	20	28
Song, et al., (2007)	Adults aged N=1503 Los Angeles, California, USA	Green parkland ratio % parkland in census block group	SCL-90-R[1]	Cross-sectional	Hierarchical linear modelling (multivariate regression that allows for analysis	The positive association between traffic stress and depressive symptoms was 'dampened' in areas with a higher green	8	20	28

Study	Participants, Area/ country	Greenspace measure	Depression/ Rumination Measure	Methodology	Analysis	Main Findings	Method Quality Score (NOS max=9)[a]	Reporting Quality Score (STROBE max=26)[b]	Total Quality Score (max=35)
					of nested data)	parkland ratio ß =−0.006, (SE=0.011, *p* <= 0.01)			

[a]Newcastle-Ottawa Scale (Wells et al., 2012)
[b] Strengthening the Reporting of Observational studies in Epidemiology checklist (von Elm et al., 2008)
[c] National Land Cover Database for the conterminous United States (Homer et al., 2011)
[d] Behavioural Risk Factor Surveillance System (CDC, 2006; Washington State Department of Health, 2007)
[e] Normalized Difference Vegetation Index (Rouse et al., 1973)
[f] Depression Anxiety and Stress Scales (Lovibond & Lovibond, 1995)
[g] Bestand Bodemgebruik (Statistics Netherlands, 2010)
[h] Patient Health Questionnaire-2 (Spitzer, Kroenke & Williams, 1999)
[i] Depression Anxiety and Stress Scales -21 (Lovibond & Lovibond, 1995)
[j] General Health Questionnaire-28 (Goldberg, 1978)
[k] Center for Epidemiological Studies Scale – Depression (Radloff, 1977)
[l] Symptoms Checklist -90-Revised (Derogatis, 1975; 1994)

Risk of Bias Within Studies

Two researchers independently assessed the quality of the methodology and reporting of the eleven included studies. Table 1 reports the quality assessment scores from the NOS, the STROBE, and the summated score, created for the purpose of this review. One study (Picavet, et al., 2016) used a cohort method, therefore methodological quality analysis was performed with a cohort version of the NOS (Wells, et al., 2012) with a total possible score of nine, whereas the highest possible score for the remaining studies was ten. Due to the difference in methodological quality scoring, the cohort study is quality assessed separately (raw scores are available in Appendix G).

The intraclass correlation coefficient for methodological quality (NOS) was good (.723) and for reporting quality (STROBE) was very good (.877). Cohen's K for methodological quality was moderate (K=.49, p<.001) and for reporting quality was good (K=.78, p<.001). The quality of the studies was acceptable within the boundaries of correlational approaches, and interpretations of results were cautious. The average score for the cross-sectional methodology was seven, ranging from six (Miles, et al., 2011) to nine (Beyer, et al., 2014; Bos, et al., 2016; McEachan, et al., 2015). The average score for the reporting quality was 20, ranging from 18 (Cohen-Cline, et al., 2015) to 24 (McEachan, et al., 2015).

A key component of the methodological quality of the studies for the current review lies in their management of potential confounding variables in the environments studied. These were on both levels of individual demographic variables, and area-level variables. The exact nature of potential individual demographic level confounders gathered and managed in analysis varied slightly between studies. For example, in addition to variables such as age, gender, education level and income, factors such as race and ethnicity (e.g. Beyer et al, 2014), immigrant status (e.g. Bos et al, 2016), and

sense of being connected to nature (e.g. Cox et al, 2017) were variably taken into account. These were included as dummy variables in initial steps of regression analyses, and sometimes weighted in relation to population-level proportions for the country in which the study was conducted (e.g. Bos et al, 2016). However, they were also considered further in some studies, for example as moderators (e.g. age and gender; Beyer et al, 2016; physical activity and socioeconomic status, McEachan et al, 2015) or as general key variables of interest to be explored (e.g. marital status, physical activity, smoking, and drinking; Min et al, 2017).

Area, or neighbourhood factors which were potential confounders were also statistically controlled for across studies (within initial steps of regression analyses), however, the geographical level at which these were measured varied with the level at which greenspace was being measures (e.g. by zipcode, by neighbourhood, or wider area). Environmental level confounders included factors such as median income, levels of employment, levels of education, and crime in the area. "The composition of environmental measures of e.g. socioeconomic deprivation varied between studies. This difference was due to variation in the collection of population statistics between governments. Different measures and combinations of environmental and social factors within an area would be computed variably to produce a measure of e.g. socioeconomic deprivation." Some studies took further environmental factors into account, particularly if these were of specific interest to their research aims, for example urbanity/rurality (Beyer et al, 2016) or traffic levels (Song et al, 2007).

Results of Individual Studies

Table 1 summarises the results of each study, including associations, odds ratios, and confidence intervals. Depression and greenspace were measured differently between

studies, providing a range of conceptualisations of the relationships (or lack thereof) between depression and greenspace. The ways in which these variables were measured are detailed below, and a summary of relationship strengths is provided in Figure 2.

Depression Measurement

Depression was measured with five different tools across the eleven included studies. Four studies (Miles, et al., 2011; Min, et al., 2017; Picavet, et al., 2016; Reklaitiene, et al., 2014) used the Center for Epidemiological Studies Depression scale (CES-D; Radloff, 1977. The CES-D comprises 20 items designed to measure depression in community samples on a four-point scale of frequency over the past week. The CES-D has been found to be an accurate, generaliseable screening tool (Cho & Kim, 1993; Vilagut, Forero, Barbaglia, & Alonso, 2016), to have high internal consistency (α=.88; Siddaway, Wood, & Taylor, 2017), and to have high convergent validity with other well-established measures of depression, such as the PHQ-9 (r=.85; Amtmann, et al., 2014).

Three studies (Beyer, et al., 2014; Bos, et al., 2016; Cox, et al., 2017) used the Depression and Anxiety Stress Scales (DASS; Lovibond, & Lovibond, 1995). The DASS comprises 42 items, measuring three 14-item subscales of depression, anxiety, and stress, on a four-point scale of extent that each item applies to the individual over the past week. The DASS has high internal consistency in both its 42-item format (α=.97 for depression subscale: Antony, Bieling, Cox, Enns, & Swinson, 1998) and 21-item format (α=.94 for depression subscale: Antony, et al., 1998; α=.85 for depression subscale: Osman, Wong, Bagge, Freedenthal, Gutierrez, & Lozano, 2012). Both 42-item and 21-item versions have been found to be reliable, and valid, with depression subscales measuring features unique to depression, over anxiety and stress (Antony, et al., 2012).

Akpinar and colleagues (2016) used the Behavioural Risk Factor Surveillance System (BRFSS; CDC, 2006; Washington State Department of Health, 2007), which

comprises a telephone interview about a wide range of health behaviours and indicators, with eight depression items in this version. The BRFSS has been found to have good reliability and validity for mental health measures, including depression (Pierannunzi, Hu, & Balluz, 2013), e.g. strong test-retest reliability for measuring depressive symptoms (K=0.71 p<.005: Kapp, Jackson-Thompson, Petroski, & Schootman, 2009).

Cohen-Cline and colleagues (2017) used the PHQ-2 (Kronke, Spitzer, & Williams, 2003) derived from the Patient Heath Questionnaire (PHQ-9; Spitzer, Kroenke, & Williams, 1999), which comprises nine items reflecting depression symptoms on a four-point scale from zero (not at all) to three (nearly every day) over the past two weeks. The PHQ-9 is a well-established measure, with high internal consistency (e.g. α= .87: Beard, Hsu, Rifkin, Busch, & Björgvinsson, 2016), and good construct validity, and specificity to depression (Beard, et al., 2016; Manea, Gilbody, & McMillan, 2015). The PHQ-2 has been found to have lower specificity than the PHQ-9, but high sensitivity to depression (Arroll, et al., 2010) and high internal consistency (e.g. α= .83: Löwe, Kroenke, & Gräfe, 2005).

McEachan and colleagues (2015) used the 'severe depression' subscale of the General Health Questionnaire (GHQ-28; Goldberg, 1978), a 28-item measure of multiple types of psychological distress, including the seven-item 'severe depression' subscale. The GHQ-28 has been found to have a stable factor structure across 15 countries, particularly the severe depression subscale (Werneke, Goldberg, Yalcin, & Ustun, 2000) with good sensitivity and specificity (Meader et al., 2011). However, due to their previous findings that GHQ-28 items may have culturally and lingusticaly-bound conceptualisations with the Born in Bradford cohort used in the study (BiB; Raynor, 2008) McEachan and colleagues chose four items they found consistent across cultural groups (Prady et al., 2013).

Song and colleagues (2007) used the Symptoms Checklist-90-Revised (SCL-90-R; Derogatis, 1975, 1994), a 90-item measure of a broad range of psychological conditions, with a 13-item depression subscale. The depression subscale has high internal consistency (e.g. α= .86; Paap, Meijer, Van Bebber, Pedersen, Karterud, Hellem, & Haraldsen, 2011; α= .89; Prinz, Nutzinger, Schulz, Petermann, Braukhaus, & Andreas, 2013), high convergent validity with the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; r= .80; Prinz, et al., 2013), and with relevant subscales within the SCL-90-R (Buckelew, Burk, Brownlee-Duffeck, Frank, & DeGood, 1998). All included studies therefore reported depression using satisfactorily established, valid, and reliable measures.

Greenspace Measurement

Greenspace was measured using three broad categories of geographical landcover tool, including satellite data, national or district landcover databases, and measures of green parkland. Four studies (Beyer, et al., 2014; Cohen-Cline, et al., 2015; Cox, et al., 2017; McEachan, et al., 2015) used the Normalized Difference Vegetation Index (NDVI; Rouse, Haas, Schell, & Deering, 1973). The NDVI is NASA's measure of green vegetation density via ongoing infrared satellite imaging of the Earth's surface, which allows its free use by researchers internationally. As plants absorb solar radiation via photosynthesis, they absorb and use wavebands of 400 to 700 nanometres, and re-emit solar radiation with longer wavelengths in the near infrared spectrum. Absorption of one spectrum and re-emission of another creates a contrast, with live vegetation appearing dark in visible, and bright in near-infrared measures. The NDVI exploits this contrast to calculate a measure of density of photosynthesising plant material ranging from -1.0 to

1.0. This creates a standardised measure of general greenspace dependent on leaf density.

Beyer and colleagues (2014) calculated mean NDVI within a 30m resolution for each census block group, which correspond to neighbourhoods of between approximately 600 to 3000 residents. They cropped cloud-covered areas from their imagery, as cloud cover interferes with the NDVI, and also used the National Land Cover Database data on percentage of tree canopy cover within census block groups as an additional measure. Cohen-Cline and colleagues (2015) used the 1km radius for census block groups, did not report adjusting for cloud cover, however, excluded participants living in areas surrounded by water. Cox and colleagues (2017) used full UK postcodes in conjunction with mapped data of vegetation of ≥0.7m in height and NDVI scores of >0.2 to provide an accurate measure to 2m resolution of greenspace density within 250m of each participant's residence. McEachan and colleagues (2015) also used participants' full UK postcodes for 100m, 200m, and 300m radii. They selected two images with least cloud cover for this measure and also determined categorical access or lack thereof to an area of greenspace larger than 5000m^2 within 300m of their residence.

Four studies used their individual national or district databases for landcover to determine greenspace (Akpinar, et al., 2016; Bos, et al., 2016; Miles, et al., 2011; Picavet, et al., 2016). Akpinar and colleagues (2016) used the American National Land Cover Data (NLCD; Homer et al., 2011) measure to classify 25m x 25m grids into five categories of greenspace, comprising urban greenspace, forest, rangeland, agriculture, and wetland. They then calculated the proportion of each category and aggregated greenspace within each zip-code area of each participant.

Bos and colleagues (2016) and Picavet and colleagues (2016) used the Dutch Land Use database (BB; Statistics Netherlands CBS, 2010). The BB differentiates

between agricultural land, urban greenspace including gardens and parks, and natural green within 25m x 25m grids. Bos and colleagues calculated the percentage of greenspace within 1km and 3km areas surrounding the central point of the general postcode of each participant in their national study, allowing for differentiation between ranges of greenspace surrounding area of residence. Picavet and colleagues (2016) also used the 1km radius, however also used a 125m radius, focusing on the area within and around the town of Doetinchem. They analysed the urban greenspace and agricultural categories separately and excluded forests and natural areas due to their low (5%) coverage within the area.

Miles and colleagues (2011) used a public land file from the Florida Geographic Data Library to determine number of acres of accessible greenspace within quarter of a mile of each census tract of each participant. They excluded privately owned greenspace such as golf courses and agricultural land, focusing on publicly accessible spaces such as forests and parks. They created a categorical variable of three broad categories of accessible greenspace density, from one (no greenspace), to two (> zero greenspace up to the 80^{th} percentile) to three (> 80^{th} percentile).

Three studies used residential proximity to parkland as a greenspace measure (Min, et al., 2017; Reklaitiene, et al., 2014; Song, et al., 2007). Min and colleagues (2017) used data from the Korean Statistical Information Service (KOSIS), which had calculated m^2 parks and green areas per capita within large administrative districts. While this provided an objective measure of greenspace, the calculation of greenspace per capita within districts that included whole cities gives a low-specificity measure of greenspace on the individual level, where depression was measured.

Conversely, Reklaitiene and colleagues (2014) used land cover datasets from the municipality for Kaunas city, Lithuania, to identify green city parks, and their proximity

to the residence of each participant. They defined residential proximity to a park as living less than 300m, or between 300m and 1km from a greenspace with 65% greenspace cover or more. This relatively increases specificity of the relationship between greenspace and depression compared with Min and colleagues' (2017) measure, however measures only one city. Song and colleagues (2007) used Geographic Information System (GIS) data from the City of Los Angeles to determine percentage of green parkland area in each of 137 census block groups. Therefore, while less specific than Reklaitiene and colleagues' park proximity, the measure covers a large area.

Syntheses of Results

Greenspace and Depression: General Greenspace

Eight of the included studies investigated the relationship between greenspace as a general measure within a geographical area, and depression. Seven of these studies (Beyer, et al., 2014; Bos, et al., 2016; Cohen-Cline, et al., 2015; Cox, et al., 2017; McEachan, et al., 2015; Miles, et al., 2011; Picavet, et al., 2016) found a negative relationship between depression and greenspace, while Akpinar and colleagues (2016) found no relationship between aggregated greenspace and depression and concluded that this may have been due to both the variability in zip-code area sizes, and variability in restorative qualities of types of greenspace.

Miles and colleagues (2011) found moderate levels of accessible greenspace (between 0.1 and 38 acres) predicted significantly lower depression scores than areas with no greenspace, however, there was no such difference found for areas of the highest levels of accessible greenspace (>38 acres). Bos and colleagues (2016) also found radial differences in the predictive relationship between greenspace and depression. The association between greenspace and depression applied within the 3km radius of

postcode, but not within 1km and that the relationship was particularly strong for females aged 18-24 years and ≥65 years. However, they also found that in males aged 45-54 years, higher percentages of greenspace predicted higher depression scores. Conversely, Picavet and colleagues (2016) found that higher levels of greenspace predicted lower depression within the 1km radius but not the 125m radius. They noted that there was low variability of greenspace density within their study area, which may have reduced sensitivity of their measure. The lack of effect within 1km radius in Bos and colleagues' (2016) study may have been in part due to their use of general postcode areas being too vague to return an effect within a close distance, whereas, as acknowledged, wider areas may take into account more extensive greenspaces such as parkland and forests. They also speculate that age and gender differences may be explained by middle-aged males being near to greenspace but unable to use it or spend time in it due to work. McEachan and colleagues (2016) found stronger negative associations between greenspace and depression in lower socioeconomic groups, and that the effect of greenspace on depression remained only for active, and not for inactive, pregnant females when adjusting for physical activity. Therefore, there is some suggestion that lifestyle factors that affect the use of greenspace may somewhat interact with its relationship with depression.

No adverse associations were found in the other studies of general greenspace and depression. McEachan and colleagues found the prevalence of depressive symptoms in the least green quintile of their study was 39% compared with 31% prevalence in the greenest quintile. There appeared to be specific relationships between depression and greenspace over other health-related outcomes. Beyer and colleagues (2014) found that higher NDVI and NDVI combined with tree canopy both better predicted lower levels of depression than anxiety or stress. Similarly, Cohen-Cline and colleagues (2015) found

that between and within twin pairs, the twin with the higher NDVI had a lower risk of depression. This result occurred despite the finding that this effect was not present for anxiety or stress within twin pairs and when adjusting for confounders such as physical activity. Cox and colleagues (2017) found that higher greenspace density was predictive of lower levels of depression symptoms despite not finding an association between greenspace and self-reported physical health.

Greenspace and Depression: Categories and Qualities of Greenspace

Aggregated greenspace measures, tree canopy, and parks were all found to predict higher depression scores on validated measures across reviewed studies. Figure 2 illustrates the radii around residences in which a relationship was found between validated measures of depression and greenspace.

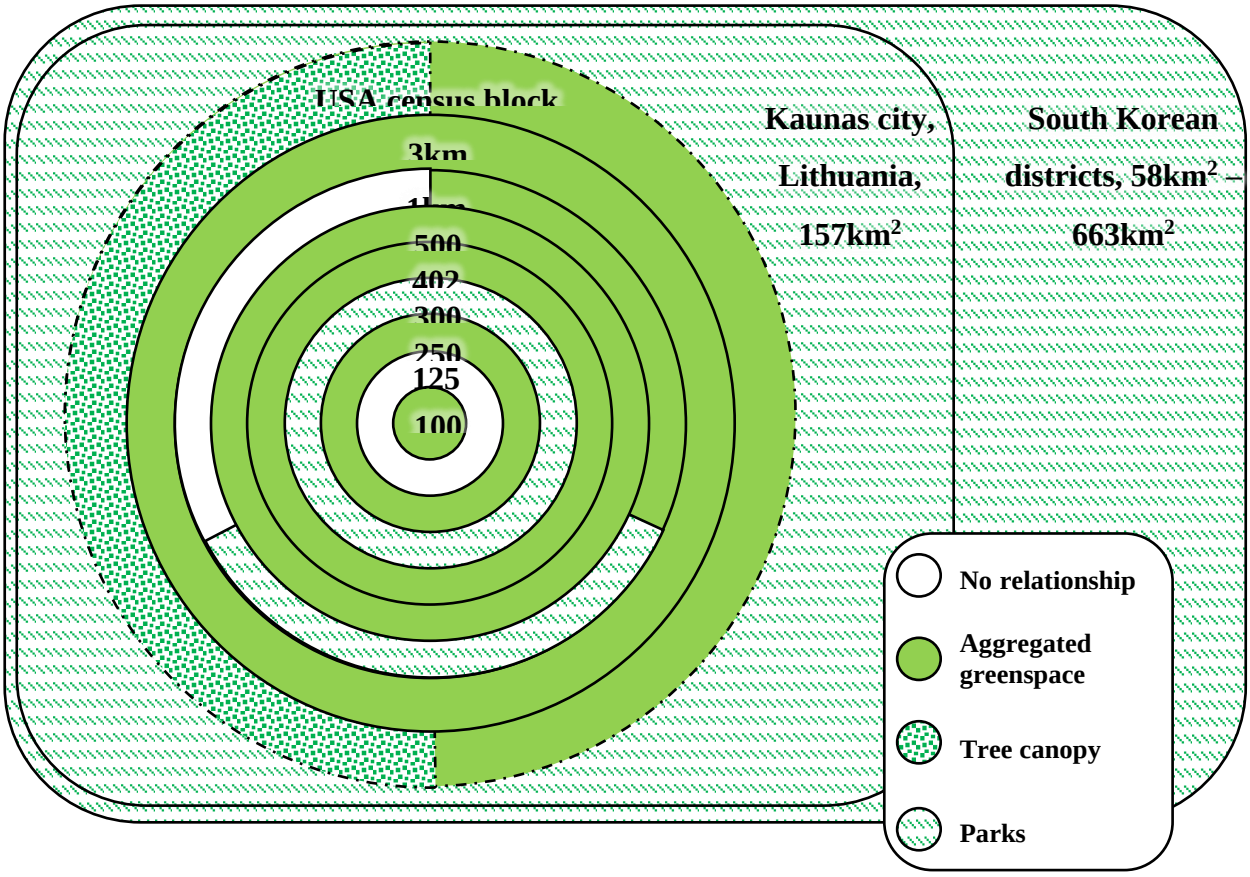

Figure 2: Radii wherein relationships were found between depression and greenspace by type.
Note: Each band represents a radius studied (N=10 studies)

The three studies that focused on parkland each found that increased green parkland predicted lower depression (Min, et al., 2017; Reklaitiene, et al., 2014; Song, et al., 2007). Min and colleagues (2017) found that participants living in areas of 33m^2 /capita or more had higher odds of depressive symptoms, suicidal ideation and suicide attempts than those living in 14.90 m2/capita or less. Reklaitiene and colleagues (2014) found that greater residential proximity of parkland predicted lower depression in females only. Song and colleagues (2007) found parkland to be predictive of lower depression, as well as reducing the positive relationship between traffic stress and depressive symptoms.

Two studies found that trees may have a significant relationship with depression in particular. Beyer and colleagues (2014) found that when taking a large range of potential confounding factors into account, proportion of tree canopy independently predicted extent of depression symptoms, more so than stress and anxiety. They found that a 25% increase in density of tree canopy predicted approximately a one-point decrease in the depression subscale of the DASS. Similarly, while Akpinar and colleagues (2016) found no relationship between aggregated greenspace and depression, they found that when they asked participants "*Now, thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?"* (Akpinar et al., 2016, p. 409) higher density of forest was predictive of fewer reported 'not good' mental health days. However, this item does not constitute a peer-reviewed measure in itself.

Risk of Bias Across Studies

Risk of selective reporting bias across studies was analysed via the STROBE. All studies failed to score for the item regarding reporting of reasons for non-participation and three

of 11 studies scored on the item regarding description of missing data for each variable of interest. However, all but two studies (Picavet et al., 2016; Reklaitiene et al., 2014) clearly and directly detailed how potential sources of bias would be addressed in their methodologies and all studies discussed potential biases and limitations and gave cautious interpretations of the meaning of their results.

Discussion

Summary of Evidence

The primary objective of the review was to investigate whether greenspace is predictive of adult depression, using existing research. This objective was fully met. The second objective was to investigate greenspace as a predictor of prevalence, duration, or recovery from depression. This was partly met in terms of prevalence, and partly in terms of duration of symptoms, but was not met in terms of recovery. The third objective, to investigate greenspace as a predictor of adult ruminative and perseverative thinking was not met, as no records were returned which both investigated this and met eligibility criteria.

Greenspace was negatively predictive of depression overall. However, while depression was measured via similarly validated self-report across studies, greenspace measurement varied widely in precision and nature. Proximity to urban greenspace was predictive of lower levels of depression, as was the density of greenspace within areas around residence, although the strength of this varied between closer and wider ranges across studies. Accuracy of approximating residence, and thus the areas around residences varied between studies, which may account for some of this variability. Although most studies found that general measures of greenspace were predictive of depression, some found that the type of greenspace was a salient factor in this pattern (e.g. Akpinar et al., 2016). Parks and trees, particularly forest or relatively dense tree

canopy may be particularly related to depression and may account for some of the relationship between aggregated greenspace and depression (Akpinar et al., 2016; Beyer et al., 2014; Min et al., 2017; Reklaitiene et al., 2014 Song et al., 2007).

In addition to their consideration as potential confounders, systemic factors such as gender may interact with the relationship between greenspace and depression, with some evidence of a stronger potentially restorative relationship for females, and studies using exclusively females finding this relationship (Bos et al., 2016; McEachan et al., 2015; Reklaitiene et al., 2014). While one study found an adverse relationship between higher greenspace percentage and depression for middle-aged males, the majority found potentially restorative relationships for males and females (Bos et al., 2016). Greater socioeconomic deprivation and greater physical activity were both found to strengthen the relationship between greenspace and measures of depression (McEachan et al., 2016).

Findings may suggest that the relationship between greenspace and depression may exist when other factors of inequality are taken into account, even when no relationship is found between greenspace and indicators of anxiety, stress, or physical health. This presents the possibility of a specific relationship between residential greenspace and the experience of depression via underlying mechanisms that may be specific to the occurrence, maintenance, or reoccurrence of depression.

Limitations

This review failed to find studies of rumination and greenspace, which precludes any ability to draw conclusions about possible relationships between greenspace and rumination as an underlying mechanism of any relationships found between greenspace and depression. Further, while this review focused on establishing whether a relationship

can be said to exist between depression and greenspace, a major limitation is the focus on correlational findings, to the exclusion of studies which may measure some causal effects of greenspace on depression.

An additional limitation is derived from the diversity across studies in methods of measuring greenspace, which prevents meaningful meta-analyses of data, necessitating narrative synthesis. Studies using national landcover databases could not control for how robust their greenspace data were from the time they were taken to the time of the study, while studies that used satellite imagery to generate their own categories of greenspace density were vulnerable to the limitations such as cloud cover. This limitation further applies to the variability in specific nature of both individual level and area level confounders controlled for between studies. While levels of socioeconomic deprivation were controlled for as potential confounders across studies, the ways in which this was measured varied by country. The diversity of greenspace measurement between studies also adversely effects the generalisability of findings, however, this may be partially mitigated by findings being relatively consistent between different nations in that negative relationships were largely found between greenspace and depression across methods of measurement. However, publication bias may account for some of the relationships found, as unpublished data were not used in this review.

Conclusions

This review revealed some evidence in support of a negative relationship between depression and residential greenspace. The nature of this relationship may be interpreted in several ways. Evidence of a negative relationship between measures of current depression and greenspace may support the concept of greenspace deprivation as a mental health inequality however, complexities of the relationship between residential greenspace deprivation and depression must be investigated further. It may be that a lack

of residential greenspace contributes to a range of environmental and social factors that constitute an external depressogenic environment.

The research detailed in this review used measures of current depression. While the depression measures used had all been validated as indicative of depression, they could not elucidate the nature of the relationship with regard to mechanisms underlying and linking residential greenspace and the cognitive, affective, physiological and behavioural composite experience of depression. It may be that greenspace is a protective factor that dampens other external depressogenic factors (such as relative deprivation) or internal depressogenic factors (such as rumination). There is evidence that depressogenic cognition may develop as a cognitive style following initial experiences of depression brought on by adversity and initiate further depression when low mood is experienced (Segal eta l, 2006). Therefore, providing relief or protection from rumination is a potential mechanism by which greenspace may be protective against recurrent depression. The dearth of research into greenspace and internal depressogenic factors leaves a conceptual gap that may be theoretically filled by ART.

The context of ART

Rumination may be a key mechanism by which adverse external experiences interact with internal experiences to produce depressogenic cognition, affect, and behaviour leading to depression and its reoccurrence (Segal et al., 2006). ART suggests that a ruminative response to the external environment and stressors may result from attention fatigue, via the unrelenting influx of demand for directed attention inherent in contemporary urban life (Kaplan, 1995; Ursin, 2005). Theoretically, greenspace is a natural break from circumstances and environments that demand directed attention, granting cognitive respite and attention restoration (Kaplan, 1995). It is possible that the main findings from studies included in this review may be explained by greenspace

providing the opportunity for restoration, contributing to reductions in depressogenic cognition such as rumination, and reducing the impact of other environmental stressors that may lead to the occurrence, maintenance, or reoccurrence of depression. Reduction in these experiences for pregnant mothers could positively influence the psychological experiences of their children (e.g. Kinsella & Monk, 2009).

The four criteria for attention restoration may provide some theoretical context for variance of results between people and between categories of greenspace. 'Compatibility' and 'being away' may be reliant on the individual's willingness, desire, and ability to shift attention during the requisite moment between directed attention and 'soft fascination' (or undirected attending) to the greenspace. It is possible that for those people, living within proximity to greenspace that is ever-inaccessible to them while being accessible to others may be an adverse experience, as relative deprivation interacts with depressogenic cognition and behaviour (Kuo & Chiang, 2013). Moreover, 'extent' (immersion) may only be possible in areas of greenspace near the home that are publicly accessible (e.g. parks or woodland) or that immerse the neighbourhood itself (e.g. dense tree canopy).

Implications for practice

Possible stronger associations between lack of greenspace in the residential environment and depression in people suffering greater socioeconomic deprivation may indicate an increased importance of the role of greenspace in prevention of depression for those who have the least access to it (e.g. Kaplan & Burman, 2010). As there is also some indication that the accessibility of immersive spaces and the density of greenspace in the neighbourhood environment may be related to depression, initiatives and policies to implement increased density (e.g. tree canopy) and accessibility (e.g. parkland, woodland, community lawn and garden space) of greenspace within neighbourhoods

high in socioeconomic deprivation and health inequalities should be enacted and evaluated.

There is some evidence that implementation of greenspace as an element of intervention for depression via reduction in rumination may be of added benefit (Bratman et al., 2015; Dinno, 2007); the results of this review support the concept of a potentially restorative relationship between greenspace and depression, however, further research into the mechanisms that may underlie this relationship is needed.

Implications for research

Continuous exploration of relationships between developmental, environmental, systemic, behavioural, cognitive, and physiological depressogenic factors may provide an emerging understanding of depression across disciplines that integrates the concept of depression across internal and external factors. The current review supports the exploration of degree, accessibility, proximity and type of greenspace as environmental contributors to the complex interaction of factors influencing depression. Future studies of the relationship between depression and greenspace will benefit from utilising greenspace measures that take variability of type of greenspace into account, and examine the relationship across multiple radii in order to prevent Type II errors. There may be less of a relationship between, for example, inaccessible agricultural greenspace far away from residential environments and depression than for urban trees and parkland and depression (Akpinar et al., 2016; Beyer et al., 2014; Min et al., 2017; Reklaitiene et al., 2014; Song et al., 2007). Areas with little differentiation in types of greenspace too close to the home may not reveal a relationship, whereas wider areas that incorporate immersive environments such as forest and large parkland may (Bos et al., 2016). Similarly, measuring areas too far from the individual's residence may miss the

immersive effects of greenspace density close enough to the home to be experienced daily (Picavet et al., 2016).

Cognitive factors underlying interactions between socioeconomic deprivation, greenspace, and depression should be investigated in future research, contributing to the understanding of nature as a potential element of depression intervention.

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Chapter 2: Empirical Paper

An investigation of residential greenspace, dispositional mindfulness, rumination and recurrent depression

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Abstract

Background: There is a need for empirical evidence to support theoretical proposals that exposure to greenspace environments can guard against depression. Facets of dispositional mindfulness have been found to predict rumination. Rumination has been found to predict relapse into depression. **Purpose:** This study explores the relationship between residential greenspace and rumination, and how this relationship may be influenced by dispositional mindfulness and number of previous episodes of depression. **Methods:** In this cross-sectional online study, multiple regression and moderation analysed data from 195 adults in England and Wales. The survey included standardised measures of rumination, depression, and mindfulness. Post codes indicated relative neighbourhood deprivation and greenspace. **Results:** Higher density parkland predicted rumination in participants living in areas of high deprivation. The 'nonjudgement' mindfulness facet strongly predicted rumination. Rumination and number of previous depression episodes were positively associated. **Conclusions:** The results of the study support the possibility that neighbourhood parks may be helpful in reducing rumination in areas of high deprivation.

Keywords

Depression; Greenspace; Mindfulness; Health Inequalities; Rumination

Introduction

Depression and Greenspace Research

Depression has been established as a serious and growing problem across the world, calling for the continuation of research into wide-reaching factors which may relieve depression across populations (WHO, 2017). There is growing interest in the relationship that different environmental conditions have with mental health and wellbeing, and how interventions can utilise these potential relationships to help ameliorate mental health difficulties (Jordan, 2015). Research suggests a negative predictive relationship between higher densities of greenspace in the residential environment and current depression (Beyer et al., 2014; Bos et al., 2016; Cohen-Cline et al., 2015; Cox et al., 2017; McEachan et al., 2015; Miles, Coutts, & Mohamadi, 2011; Picavet et al., 2016). Higher odds of developing depression in urban environments lower in greenspace have also been demonstrated (Reklaitiene et al., 2014). However, greenspace has also been found to have no relationship with measures of current depression (e.g. Akpinar, Barbosa-Leiker, & Brooks, 2016).

The study of green space in relation to depression has varied from research into existing psychological interventions with and without a 'nature' component, to the study of the psychoecological impact of greenspace in the residential environment. For example, it has been suggested that the effectiveness of psychological and psycho-ecological interventions for depression may be increased by including exposure to greenspaces (e.g. Bratman, Daily, Levy, & Gross, 2015; Dinno, 2007). These findings occur independently of potential confounders such as physical exercise uplifting mood, for example greenspace has been found salutogenic for psychological wellbeing independently of physical activity (Groenewegen et al., 2012). Exercise via walking and

running have been shown to be more effective for mood in natural outdoor greenspace than in synthetic greenspace (Knight et al., 2010).

Cross-sectional studies have not explored the relationship between greenspace and recurrent depression, so it is not yet possible to infer conclusions regarding underlying mechanisms. Inconsistency in findings may be in part due to the extensive variability in how greenspace has been measured (Bos et al., 2016; Akpinar et al., 2016). For example, it is possible that some types of greenspace within an urban environment are more salient than others to depression. Higher neighbourhood densities of parks and trees may predict lower depression scores, in some studies this has been over and above aggregated measures of greenspace (Min et al., 2017; Reklaitiene et al., 2014; Song et al., 2007). Moreover, the radius or space around the residence in which greenspace is measured may be a factor in whether a relationship is found with depression. Measurements too close to home miss large areas of urban parkland, while measures of aggregated greenspace over large areas may be too vague (Akpinar et al., 2016; Beyer et al., 2014; Bos et al., 2016; Min et al., 2017; Picavet et al., 2016; Reklaitiene et al., 2014; Song et al., 2007).

Theoretical links between depression and greenspace

A range of theories have been proposed to account for how environments might affect mental health. The Biophilia Hypothesis (Kellert & Wilson, 1993; Wilson, 1984), for example, presents an evolutionary argument for the maintenance over time of an innate, universal subconscious orientation toward ‘nature’ in humans. The hypothesis has two main assumptions. First, that deriving psychological wellbeing from engaging with nature has been adaptive in harnessing the natural environment, flora and fauna for

physical survival, and that now a sense of needing to be close to nature both physically and psychologically pervades. Second, through industrialisation, the advancement of technology and infrastructure and the urbanisation of life, humans have become disconnected from nature, including from living in natural landscapes, which causes psychological suffering (Kellert, 1993). While Biophilia provides an evolutionary, unconscious argument, potential conscious, cognitive mechanisms by which nature may impact mood and experiences are not explored. An alternative theory, known as Attention Restoration Theory (ART) posits contemporary urban life as deleterious to attentional capacity, which can be restored by time spent in natural environments (ART: Kaplan, 1995; Kaplan & Kaplan, 1989).

Within ART, the sustained effort required to maintain attention to daily and working tasks within distracting contemporary environments is termed 'directed attention', and the resultant depletion of attentional capacity 'attention fatigue' (Kaplan, 1995; Kaplan & Berman, 2010). The psychological impact of attention fatigue may be substantial, as the capacity for problem solving, focusing attention, positive mood and emotional regulation are depleted (Hartig, Mang, & Evans, 1991; Kaplan, 1995; Ursin, 2005).

According to the ART framework, spending time surrounded by natural greenspace (grass, trees, flora) promotes attention restoration as the brain employs a more calming, effortless attention (Kaplan, 1995). In order for this process to function, four criteria must be fulfilled, comprising 'soft fascination', in which the environment is gently gratifying and stimulating, allowing for effortless attention; 'extent', in which the natural environment is experienced immersively; 'being away', in which the experience provides escape from directed attention; and 'compatibility', in which the individual finds nature agreeable (Kaplan, 1995).

Although ART provides theoretical links between cognition and environment via the four criteria of soft fascination, extent, being away, and compatibility, research has been required to investigate the exact nature of the ways in which these features may alter cognition and emotion, and whether this theory is well-evidenced. Meta-analysis of ART's evidence base was conducted by Ohly and colleagues (2016). Despite reporting some evidence in support of benefits to digit span both forwards and backwards, as well as trail making following exposure to natural environments in three meta analyses, these results were limited to higher quality studies. Ohly and colleagues (2016) found that support for ART was limited by low quality in study methodology and reporting in ten further meta-analyses conducted.

Despite support for the theoretical assumption that nature aids short-term memory and reasoning, it is unknown whether e.g. maladaptive cognitive patterns are reduced or adaptive cognitive patterns increased to increase mood. While ART provides some focus on cognitive processes which may be seen as an improvement to the unconscious focus of the Biophilia hypothesis in terms of practical applications of the theory, ART may be missing links between the cognitive and affective elements of a relationship between greenspace and levels of psychological wellbeing. For example, Stevens (2014) primed participants to experience positive and negative affect, and found that priming for negative affect resulted in natural environments being rated as more restorative than urban environments within categories of 'fascination' and 'being away'. 'Fascination' was the only condition with an interaction effect whereby negative priming resulted in a higher mean 'restoration' rating. Stevens therefore argued that ART may be overly focusing on a one-way process. That is, ART suggests that nature restores cognitive attentional capacity which allows restoration of positive affect, whereas the

study provided evidence of affect impacting on how participants experienced the environment as cognitively restorative.

Despite its criticisms, given the existence of evidence in its support, ART provokes questions as to how other sociodemographic, and socio-environmental variables that may impact on both affect and attention capacity may interact with greenspace in the development, maintenance and relapse into depression. It also leads to questions of how known cognitive mechanisms underlying the process of the redevelopment of depression, such as rumination, may interact with greenspace and attention.

Depression and Socioeconomic Deprivation

The social stress paradigm indicates that socioeconomic inequality is often also mental health inequality, as socioeconomic stressors bring about and interact with depressogenic cognitive style (Schwartz & Meyer, 2010). Systemic and socioeconomic adversity both predict depression, from unemployment (Pelzer, Schaffrath & Vernaleken, 2014), debt (Richardson, Elliott & Roberts, 2013), and adverse working conditions (Theorell et al., 2015) to social factors such as race (Barnes, & Bates, 2017), sexual identity (Ploederl & Tremblay, 2015) and gender (Alibrahim, Al-Sadat & Elawad, 2010). Women, for example, may be socialised to be more ruminative in response to adversity which may in part explain their greater rates of depression (Johnson & Whisman, 2013; Kwon et al., 2013; Whiteman & Mangels, 2016).

Absolute and relative socioeconomic inequality predicts depression (Beshai et al. 2017; Kuo & Chiang, 2013). Socioeconomic inequality may also indicate mental health inequality via residential environmental factors, which are recently the subject of a burgeoning field of psycho-ecological research into environmental factors and depression (e.g. Barnett et al., 2017; Gong et al., 2016; Lee & Maheswaran, 2011). Both

objective neighbourhood effects and perceived deprivation in the neighbourhood can predict psychological distress (Gong et al., 2016). The concept of the development of depression must therefore take into account 'external' factors (such as personal and socioeconomic adversity), the 'internal' factors of depressogenic cognition, and the interaction between the two. If a situation is relentlessly and hopelessly adverse, one may learn to feel hopeless in response to adversity, and become entrapped in ruminative cognition without resolution to the external source of suffering (Beshai et al., 2017). It is therefore clear that sociodemographic, and environmental level factors must be taken into account in greenspace research, not only as potential confounders to the relationship between greenspace and depression, but as potentially interacting with greenspace as factors which may influence people cognitively and affectively, influencing the occurrence and recurrence of depression.

The cognitive processes which ART proposes as affected by greenspace are attentional in nature. Rumination is proposed within ART to occur as a by-product of attention fatigue. As rumination is investigated within depression research as a key underlying mechanism, particularly in the reoccurrence of depression, it may warrant further investigation as a potential variable in the relationship between greenspace and depression.

Rumination and Depression

Two major frameworks that seek to describe the cognitive process underlying the development of depression are the Hopelessness model (Abramson et al., 1989) and Response Style Theory (RST; Nolen-Hoeksema et al., 1992). While the Hopelessness model describes negative inferences and hopelessness, RST describes brooding and rumination as a passive attention focused on distress in a pervasive, perseverative cycle

(Nolen-Hoeksema et al., 1992). Both models have been evidenced (Abramson, et al., 2002; Treynor, et al., 2003). RST and the Hopelessness model combine to describe a process by which adversity creates learned responses of hopelessness and negative inferences.

Latent patterns of depressogenic thinking may easily become reactivated by low mood (Svendsen et al., 2017). The response is further rumination on the low mood, which exacerbates it and furthers hopelessness, resulting in depression (Pössel & Winkeljohn Black, 2017; Segal et al., 2006; Spasojevic´& Alloy, 2001; Zawadzki, 2015). If ruminative thinking may be a key cognitive factor underlying the development, and re-development of depression, it is arguable that a cognitive style that selectively draws attention to a chosen subject should be investigated as a potential protective factor. One such proposed mastery of attention is mindfulness.

Mindfulness

There are many proposed definitions of mindfulness. Within the secular context, it can be conceptualised as a form of directed attention that employs conscious choice of subject, with the ability to redirect attention to that subject following distraction to internal or external stimuli (Kabat-Zinn, 2015). The dispassionate aspects of this intentional form of paying attention derive from the discipline of observing and attending to the subject, while returning attention from internal stimuli, thus preventing reactive responses such as emotive reasoning (Kabat-Zinn, 2009; Kabat-Zinn, 2015). Attentional processes are also key to the 'operational definition' of mindfulness proposed by Bishop and colleagues (2004). Within this definition, there are two major components to mindfulness, including both the self-regulation of attention such that it can maintain focus on one's immediate experience and a curious, open, accepting focus on the present

moment (Bishop et al, 2004). Within this definition, Bishop and colleagues (2004) delineate the process wherein the conscious noticing of attention wandering to a thought, and the redirection of attention to the present moment inhibits secondary, or recurrent elaborative processing of the thought. Defined in this way, mindfulness operates as the antithesis to ruminative thinking. Further elaborating this process, the Liverpool Mindfulness Model (Malinowski, 2012) illustrates the operational procedure of mindfulness practice honing the individual's ability to attend while being cognitively and emotionally flexible. These processes combine and mutually enhance one another to form a state of non-judging awareness, which can positively influence behaviour, physical wellbeing, and emotional wellbeing (Malinowski, 2012).

Mindfulness can also be conceptualised as a constellation of dispositional traits, as individuals may have differing tendencies to *observe* and *describe* their experiences, *act with awareness*, and respond to inner experience in a *non-judgmental* and *non-reactive* manner (Baer et al., 2008). The Five Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) measures the following aspects of mindfulness: *acting with awareness*; *observing*; *describing*; *non-judging of inner experiences* and *non-reactivity to inner experiences* as separate dispositional traits which can comprise an overall composition of dispositional mindfulness that varies between individuals. This constellation of different facets may have distinct relationships with aspects of attention. For example, *acting with awareness* and *observing* may slow down response times during attentional tasks, however, slower decision making and communicating of those decisions may be a result of taking the time to attend more intensely and not an indication of quality of attention (Di Francesco et al., 2017).

Mindfulness: Reversing rumination?

Mindfulness-based interventions have demonstrably reduced risk of depression relapse (Clarke, Mayo-Wilson, Kenny, & Pilling 2015; Crane et al., 2014; Piet & Hougaard, 2011). Dispositional mindfulness has also been demonstrated as beneficial to psychological wellbeing (Bowlin & Baer, 2012; Crane et al., 2010). Mindfulness has been found to moderate the relationship between unavoidable adverse events and low mood (Bergomi et al., 2013). This may be in part due to mindful cognitive style countering depressogenic cognitions in response to low mood which predict relapse into recurrent depression (Crane et al., 2010; Crane et al., 2014; Radford et al., 2014). Multiple investigations into mindfulness-based cognitive therapy have revealed a preventative effect from relapse into depression (Piet & Hougard, 2011). Furthermore, dispositional mindfulness has been found to be negatively associated with the attribution of happiness and wellbeing as contingent on external factors in depressed individuals (Crane et al., 2010). Research has indicated that higher mindfulness predicts both reduced rumination and reduced recurrence of depression (Kearns et al., 2016). In their study, Radford et al (2014) found that dispositional mindfulness protected against perseverative negative thinking during remission more effectively for those who have experienced a greater number of episodes of depression.

ART predicts that capacity for directed attention depletes over time, particularly when surrounded by stressful distraction leading to attention fatigue (Kaplan, 1995). From an ART perspective, attention fatigue would deplete an individual's capacity to be mindful. Equally however, the capacity to be mindful may be enhanced by exposure to natural environments and the restorative impact that this can have on attention. An additional possibility that ART gives rise to is that elevated levels of mindfulness (and

the attentional control it gives rise to) may reduce the impact of the urban environment on attention.

Rationale for the current study

A negative relationship between residential greenspace and measures of current depression has been suggested in recent research such that a lack of neighbourhood greenspace could be considered as a mental health inequality (e.g. Beyer et al., 2014; Bos et al., 2016; Min et al., 2017; Picavet et al., 2016; Reklaitiene et al., 2014). ART would suggest an agreeable, immersive enough greenspace around the home, in which a sense of escape from stressors can be experienced would provide a source of soft fascination, which would replenish the attention fatigue caused by directed attention in stressful circumstances (Kaplan, 1995).

Facets of mindfulness that allow for mastery over attention to the external world may reduce attention fatigue and allow switching attention to the external environment, while non-judging and *non-reactivity to inner experience* counter the depressogenic tendency to ruminate (e.g. Radford et al., 2014). As rumination has been found to develop with recurrent depressive episodes, dispositional mindfulness has been found preventative for relapse (Radford et al., 2014).

As ART provides theoretical reasoning that the relationship between residential greenspace and depression may be due to attentional factors, and as rumination and depression are related to depressive relapse, the current study aims to investigate relationships between greenspace, socioeconomic deprivation, facets of dispositional mindfulness, rumination, and the number of previous episodes of depression an individual has experienced. Previous research has investigated residential greenspace and current depression, but not number of previous episodes, and has yet to include cognitive

mechanisms thought to underlie relapse into depression and its prevention, such as rumination and mindfulness.

Aims and Hypotheses

The current study aimed to investigate the relationship between (1) two aspects of neighbourhood environment (relative deprivation and greenspace), and 2) two cognitive mechanisms (facets of dispositional mindfulness and rumination) in people with self-reported recurrent depression. The following hypotheses were investigated:

1. Rumination will be negatively related to greenspace and facets of mindfulness, Rumination will be positively related with number of self-reported depressive episodes and relative environmental socioeconomic deprivation.
2. Neighbourhood environment, facets of mindfulness and self-reported number of depressive episodes will predict rumination, after controlling for mindfulness practice and reflection.
3. Recurrent depression will moderate the relationship between facets of mindfulness and rumination
4. An indirect effect is hypothesised between greenspace and rumination, moderated by SED

Method

Participants

One hundred and ninety-five participants were eligible for final analysis for the current study. They were 161 females (aged 18-59, mean age=35.6), 33 males (aged 18-59, mean age=33.3), and one person who identified as non-gendered, residing in England (n=165, 84.6%) or Wales (n=30, 14.4%), and identified as mostly White British (n=168.

86.2%), White other (n=9, 4.6%) or Black/Minority Ethnic (n=18, 9.2%). See Table 1 for further demographic information for the sample.

Inclusion and Exclusion Criteria

The survey served two research projects including the current study, to reduce participant burden. The other project examined greenspace in relation to indicators of stress. Participants were eligible for the current study if they were adults who resided in England or Wales, were not depressed at the time of taking part, but self-reported that they had experienced depression at least once before. Current depression was screened via a score of 15 or more on the PHQ-9 (Spitzer, Kroneke, & Williams, 1999), or self-reported depression within the last month by answering positively to phrased questions adopted from SCID-I-NP (First et al., 2002). The decision was made to screen out current depression to prevent current depressive experiences from acting as an extraneous variable as previous episodes of depression were a variable of interest. It was also considered that asking participants who are currently depressed to participate in a study involving depression may be unethical if their current experiences were not to be utilised in the study.

Participants self-reported whether they had experienced depression and the number of times, and were screened out of the current study if they reported zero. The decision was taken to use the number of depressive episodes rather than a measure of current depression 'symptoms' or 'traits', as rumination was of interest as a frequently underlying factor for the experience of multiple episodes of depression. The process of inclusion is illustrated in Figure 1.

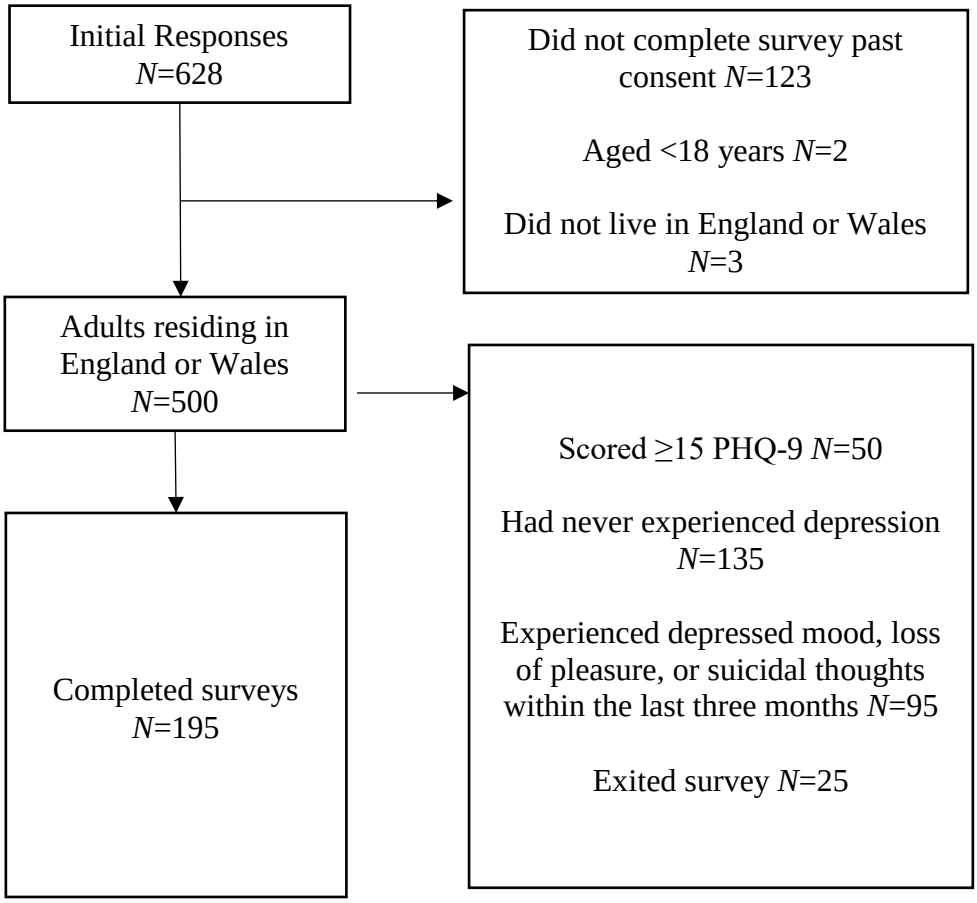

Figure 3: Flowchart of participant study completion

Table 2: Demographic data

Demographics	*N*	*% Sample*
Gender		
Females	161	82.56
Males	33	16.92
Non-gendered	1	0.51
Employment		
Full time	105	53.8
Part time	33	16.9
Self employed	16	8.2
Unemployed	11	5.7
Student	26	13.3
Retired	4	2.1
Annual income		
<£10,000	41	21.0
£10,000 - £19,000	44	22.6
£20,000 – £29,000	62	31.8
>£30,000	29	14.9
Mental health diagnosis		
No	162	83.1
Yes	33	16.9
Mental Health Service Access		
Never	117	60.0
Previously	59	30.3
Currently	19	9.7
Medication		
None	128	65.6
Antidepressants (unspecified)	65	33.3
Stimulants	1	0.5
Anti-seizure	1	0.5
Accessed mindfulness-based psychological therapy		
No	164	84.1
Yes	31	15.9
Accessed mindfulness training		
No	150	76.9
Yes	45	23.1
Mindfulness training accessed		
Taster day	2	1.0
Short course	15	7.7
Online course	2	1.0
Mobile application	6	3.1
Self-help book	11	5.6
Group	9	4.6
Mindfulness Practice		
Never	105	53.8
Previously	46	23.6
Monthly	12	6.2
Weekly	18	9.2
Daily	14	7.2
Other meditation practice		
No	162	83.1
Yes	33	16.9

Design

This study used a cross-sectional design. The raw data for this paper was generated using Qualtrics software © 2017, which also hosted the platform for online survey completion (Qualtrics, 2005).

Service user/carer involvement

Members of the University of Liverpool's Mindfulness co-production research group were involved in the design of the study, with a collaboration with the MerseyForest (http://www.merseyforest.org.uk) to explore mindfulness and greenspace initiated the current study. The Mersey Forest is the largest community forest in England, initiated in 1990 by the as part of the Community Forest programme launched by the government to increase greenspace and biodiversity in urban areas. An expert-by-experience was further involved in the design of the participant information and consent materials, and provided consultation to the author on the experience of participation at the testing stage before the online survey was live.

Power Calculation

Power analysis using G*Power 3 (Faul et al., 2007) for multiple regression with 11 independent variables (1=environmental deprivation; 2=green space within 3KM; 3=greenspace within 250m; 4-7=mindfulness facets: (4) *non-reactivity to inner experience*, (5) *non-judging of inner experience*, (6) *describe*, (7) *acting with awareness;* 8=previous episodes of depression; 9=age), an alpha of 0.05, power of 0.8, and an effect size of 0.15 indicated a sample size of 123. Fritz and MacKinnon (2007) indicated that for a mediation analysis using bias-corrected bootstrapping accounting for high alpha and beta variance, a sample size of at least 148 is required. The higher number of 148 was selected for this study, and power was met for the full sample at 195 participants and the smallest sample with missing data at 158.

Recruitment

Recruitment for the project was undertaken via social media as the survey was online and participants were sought from across England and Wales. A Twitter account (@MindNatResearch) and a Facebook page (https://www.facebook.com/mindfulnessthinkingenvironments/) were used to draw attention to the research. A website with a blog (https://mindfulnessnatureresearch.weebly.com) provided a platform for directing participants to the study, an additional space for participant information and an additional channel to contact the research team if desired. Participants had the option online to be entered into a prize draw for one of six £25 Amazon vouchers.

Ethical Approval

The current study received sponsorship, review committee approval (Appendix H), and ethical approval from the University of Liverpool research ethics committee (research ethics number 0392, Appendix I). In order to avoid any potential exacerbation of existing psychological distress, it was a requirement of the study that participants were not depressed at the time of taking part. This was screened via the PHQ-9 and self-reported anhedonia, low mood, or suicidality within three months. Environmental measures were limited to those quantifiable via postcode to reduce participant burden. Postcodes were deleted from the data file when they had been coded into environmental measures. The study followed the British Psychological Society (BPS) code of human research ethics (BPS, 2014) and ethics guidelines for internet-mediated research (BPS, 2017).

Procedure

The survey was open from 29th June 2016 to 23rd January 2017. Following participant information (Appendix J), consent (Appendix K), and demographic information, each of the psychological measures was coded as a block, and their order randomised by the software. If a participant was excluded on the basis of a PHQ-9 score of 15 or above, or for self-reporting feeling depressed or down, losing pleasure or interest in activities, or suicidality during the past three months, they were directed to sources of information and support. All participants who were excluded from the survey before completion, and those who completed the survey were thanked for their time and offered a place in the prize draw and the opportunity to give their email to receive information about the outcomes of the study.

Measures

Environmental Measures

Age, ethnicity, gender, income, education, mental health, medication, mindfulness experience and practice were sought as demographic information. Full UK postcodes were sought as an indicator of relative environmental deprivation (deprivation measured within an area, relative to other areas) rather than individual deprivation (personal or family level deprivation such as poverty, debt, etc.), which was determined via the English Indices of multiple deprivation (IMD: Welsh Government Ministry of Housing, Communities, & Local Government, 2015) and the Welsh Indices of Multiple Deprivation (WIMD: Knowledge and Analytical Services, 2014). Postcodes were re-coded to IMD and WIMD codes and designated greenspace IDs.

Indices of Multiple Deprivation

These data are published in a series of spreadsheets, and postcodes provided by participants were re-coded into Lower-layer Super Output Areas (LSOAs). English

LSOAs are small areas with an average of 1500 residents, and Welsh LSOAs have an average of 1600 residents. The indices measure broadly similar constructs across England and Wales. The English indices measure income, employment, health, education, barriers to housing and services, crime, and living environment. The Welsh indices measure income, employment, health, education, access to services, community safety, physical environment, and housing. Each index gives a composite score for each area of the country, ranked in relation to each other LSOA. The English LSOAs are ranked from one (most deprived) to 32,844 (least deprived) while the Welsh indices are ranked from 1 (most deprived) to 1,909 (least deprived). LSOA ranks are split into deciles of relative deprivation, reflecting one (most deprived) to 10 (least deprived) decile in the country. It should be noted that LSOA deciles reflect relative deprivation level, not affluence and that less deprived areas (i.e. sixth to tenth deciles) are not necessarily the most affluent.

Green Space Measure

Greenspace was calculated in radii of 3km and 250m around each postcode as previous research has found a relationship between current depression and greenspace at both walkable distances from the home and spaces large enough to encompass large areas of greenspace such as forest or parkland (Akpinar et al., 2016; Beyer et al., 2014; Bos et al., 2016; Min et al., 2017; Picavet et al., 2016; Reklaitiene et al., 2014; Song et al., 2007). Relationships between measures of current depression and greenspace have been found at 250m and 3km radii (Bos et al., 2016; Cox et al., 2017).

The Mersey Forest's GIS Co-ordinator located postcodes within Ordinance Survey's Code-Point open dataset. The co-ordinator drew circles of each radius around each postcode and intersected them with Ordnance Survey's MasterMap Greenspace Layer, which revealed urban greenspace. The percentage within each circle was plotted

by primary function (e.g. public parks, religious grounds, private gardens) and aggregated greenspace percentage was calculated. Previous research has revealed a potential effect of greenspace type, particularly regarding urban parks, on current depression (e.g. Akpinar et al., 2016; Reklaitiene et al., 2014). Accessibility of greenspace may also be salient to current depression (e.g. Akpinar et al., 2016; Bos et al., 2016). Therefore, an aggregated urban greenspace measure excluding private gardens was investigated, as well as percentage of public parks within both radii. The percentage of each circle covered by urban areas, as defined by Ordnance Survey for the purpose of developing the MasterMap Greenspace Layer, was also calculated. Analysis was carried out in Esri ArcGIS Desktop (version 10.3.1).

Mental Health/Psychological Measures

The Patient Health Questionnaire (PHQ-9; Spitzer, Kroneke, & Williams, 1999)

The PHQ-9 is a nine item measure of depression, scored on a Likert scale from zero (not at all) to three (every day). The PHQ-9 has been found to have high internal consistency (e.g. Pinto-Meza Serrano-Blanco, et al., 2005) and acceptable internal consistency in the current study for the 500 participants prior to exclusion of those scoring 15 or more (α =.92) and for the 195 included participants scoring below 15 (α =.73). The PHQ-9 provided the initial screening measure for current depression. Participants with a score of 15 or above were excluded, as this score indicates depression requiring treatment (Spitzer, Kroneke & Williams, 1999).

Self reported past history of depression

Number of self-reported depressive episodes were sought using questions derived from Module A (mood episodes) of the research version of the Structured Clinical Interview for DSM-IV-TR Axis 1 Disorders: Research Version, Non-Patient Edition (SCID-I/NP;

First, Spitzer, Gibbon, & Williams, 2002). This is consistent with DSM-IV criteria for depression and has high reliability (Zanarini et al., 2000). Anhedonia, low mood and suicidality were explored as indicators of past depression. Participants were determined to have experienced depression if they responded positively to any of the three items: (1)"Have you ever had a period when you were feeling depressed or down most of the day nearly every day for at least two weeks?"; (2)"What about a time of at least two weeks when you lost interest or pleasure in things you usually enjoyed?"; or (3)"Have you had a period of at least two weeks when things were so bad that you were thinking a lot about death or that you would be better off dead?". The items were added to the online survey in written form and answered via option selection as with other survey items.

Rumination-Reflection Questionnaire (RRQ; Trapnell & Campbell, 1999)

The RRQ (Appendix L) is a 24-item self-report measure of ruminative and reflective tendencies, measured on a five point Likert scale ranging from "strongly agree (1)" to "strongly disagree (5)". Trapnell and Campbell found high construct validity for the RRQ, including an association between the rumination subscale and neuroticism, and the reflection scale and openness to experience. In the current study internal consistency was high for the total RRQ (α =.86); the rumination subscale (α =.92) and the reflection subscale (α =.92). The RRQ was designed to distinguish ruminative and reflective self-focussed attention (Trapnell & Campbell, 1999). The RRQ was used to ensure rumination was measured as a valid construct, independently of reflective self-focused attention.

Perseverative Thinking Questionnaire (PTQ; Ehring et al., 2011)

The PTQ (Appendix M) is a 15-item self-report measure of ruminative cognition, measured on a five point Likert scale ranging from "never (0)" to "almost always (4)".

The English version of the PTQ has high internal consistency (α = .95) and convergent validity with previous rumination and worry scales (Ehring et al., 2011), and had high internal consistency in the current study (α =.95). Items focus on process over content, so that rumination is captured within the context of thinking style. The PTQ was used to measure rumination as a process of perseverative cognition.

The Five Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006)

The FFMQ (Appendix N) is a 39-item self-report measure of five facets of mindfulness that emerged from factor analysis of existing mindfulness measures (Baer et al., 2006). The five facets are: *observing*; *describing*; *acting with awareness*; *non-judging of inner experience*; and *non-reactivity to inner experience* (Baer at al, 2006). Baer and colleagues (2008) found high construct validity for the FFMQ, including mediation of the relationship between meditation and wellbeing. In the current study internal consistency was high for the total FFMQ (α =.91); the *observe* subscale (α =.83); the *describe* subscale (α =.91); the *act with awareness* subscale (α =.87); the non-judging of inner experience subscale (α =.91); and the *non-reactivity to inner experience* subscale (α =.81). In a community sample of non-meditators, the '*observe*' subscale has been more associated with a ruminative observation, and the remaining facets have provided a more valid constellation of mindfulness (Williams et al., 2014). Therefore, in the current study, the *observe* subscale was removed and the remaining four facets were included in the study

Missing data

Incomplete items triggered a prompt to complete the full set of items for each scale, therefore there were no missing data within psychological measures of interest. If the participants exited the survey early, data was missing from whole scales or subscales as blocked in Qualtrics. The order of all scales following demographic information was randomised, so there is a spread of missing subscales. For the FFMQ and its subscales, and the rumination subscale of the RRQ, 20 cases of data were missing (10.3%). For the reflection subscale of the RRQ, and the PTQ and its subscales, there were 15 cases of missing data (7.7%). No imputation of missing data was performed and cases were excluded pairwise for all correlational analyses.

There were some missing residential data, for example, wherein two participants gave only the first half of their postcodes (1.0%), two declined to give their postcodes (1.0%), six (3.1%) gave postcodes that were not identifiable via the IMDs, the Ordinance Survey (OS), or UK postcode finders, although one of these postcodes generated a LSOA, which led to seven cases of missing data regarding environmental deprivation (3.6%). A further 12 cases (6.2%) were available for environmental deprivation coding, but were more than 3km from any urban terrain, according to OS data. These were not included in urban greenspace coding, but were coded for percentage urban space.

Urbanity data were unavailable for 11 cases within 3km of residence (5.6%) and 19 cases within 250m of residence (9.7%). Public parks data were unavailable for 37 cases within 250m of residence (19.0%) and 25 cases within 3km (12.8%). Private garden data were unavailable for 32 cases within 250m of residence (16.4%), and 22 cases within 3km (11.3%). Unadjusted aggregated greenspace data were missing for 31 cases within 250m of residence (15.9%) and 23 cases within 3km (11.8%). Aggregated greenspace percentage excluding private gardens was missing for 32 cases within 250m

(16.4%) and 23 cases within 3km (11.8%). Missing data were excluded pairwise for all measures.

Data Analysis Procedure

The IBM Statistical Package for Social Sciences (SPSS, version 24) was used for statistical analysis of the data. Preliminary screening for correct data download, data entry, and outliers was conducted. Post codes were coded into identification numbers for greenspace percentages, and into multiple deprivation index codes, and deleted from the database. Data were prepared via removal of excluded cases, reverse-scoring items as appropriate, and computing subscales and totals for each scale.

In line with recommendations for populations of non-meditators, the '*observe*' subscale of the FFMQ was removed (Williams et al., 2014). Parametric assumptions of normality and homogeneity of variance were checked via Kolmogorov-Smirnov and Levene's tests, as well as visual appraisal of histograms, Normal Q-Q plots and boxplots.

Frequency of depressive episodes, percentage of public parks within 3km and 250m radii, and percentage of urban terrain within 250m radius variables violated assumptions of normality. Further, Kolmogorov-Smirnov statistics revealed significant results for all measures apart from the *describe* subscale of the FFMQ; PTQ; and the reflection subscale of the RRQ.

Levene's test indicated a small but significant difference between countries of residence (England or Wales) for the outcome variable of rumination (U=.03, p=.02). Given the effect size falls within the small range (Cohen, 1988), country of residence was not controlled for in further analyses. Group differences on predictor variables are reported in Appendix O.

Analysis of hypothesis one

To test hypothesis one, the relationship between rumination and number of depressive episodes, SED, greenspace and facets of mindfulness, non-parametric Spearman's correlation was used. Spearman's correlation was also used to test the relationships between the other independent variables explored.

Analysis of hypothesis two

Hierarchical multiple regression was carried out to investigate hypothesis two. Multicollinearity diagnostics revealed expected high variation inflation factors (VIF) between the total FFMQ and its subscales, therefore it was excluded and its subscales included. All other VIFs were under 10.

Analysis of hypothesis three

Moderation analysis tested hypothesis three, using only significant predictors from regression analysis as predictor variables. Bias-corrected and accelerated bootstrap percentile confidence intervals (5,000 resamples) were calculated for total and indirect effects. Moderation followed the Hayes (2013) method using the PROCESS macro for SPSS (model one).

Analysis of hypothesis four

Moderation analyses tested hypothesis four, for suppression effects of SED on the relationship between rumination and greenspace, using Hayes' model one (2013).

Results

Descriptive Statistics

The means and standard deviations for each of the variables of interest are reported in Table 3.

Table 3: Descriptive Data for Mental Health/Psychological Measures

Measure	*N*	Mean	SD	Range	Normative Mean (SD)
FFMQ					
Describe subscale of FFMQ	175	27.15	6.36	10-40	24.63 (7.06)
Act with Awareness subscale of FFMQ	175	24.75	5.26	9-40	24.57 (6.57)
Nonjudgement subscale of FFMQ	175	26.04	6.72	9-40	23.85 (7.33)
Non-reactivity subscale of FFMQ	175	20.54	4.54	7-31	19.53 (4.88)
Total FFMQ	175	125.02	18.42	66-170	*
Total FFMQ without *Observe* subscale	175	98.48	16.11	46-136	*
RRQ					
Rumination subscale of RRQ	175	3.62	0.72	2.00-5.00	3.46 (0.71)
Reflection subscale of RRQ	180	3.36	0.74	1.67-5.00	3.14 (0.76)
Total PTQ	180	44.13	10.59	15-74	20.97 (12.73)
Depressive episodes	195	3.09	3.15	1-20	*
Environmental Measures					
Urban space within 250m	176	90.44	27.29	0-100	*
Urban space within 3km	184	61.66	30.59	0-100	*
Greenspace within 250m	163	22.64	14.08	3.40-63.61	*
Greenspace within 3km	172	25.36	9.11	0.36-49.84	*
Parks within 250m	158	2.31	6.41	0-36.26	*
Parks within 3km	170	3.20	3.12	0-19.02	*
SED (LSOA decile)	188	4.96	2.78	1-10	*

Note: Normative data derived from: FFMQ (Baer et al., 2008); PTQ (Nota & Coles, 2018); RRQ subscales (Trapnell & Campbell, 1999); *no expected norm.

Testing of Hypothesis one: Correlation analysis

Spearman's correlation coefficient was conducted to test the first hypothesis, where rumination will be negatively correlated with facets of mindfulness and greenspace and positively related with depressive episodes and relative deprivation. (see Table 4, where rumination is measured via the PTQ, shown on the 9th numbered row and column). In

support of the hypothesis, rumination was positively correlated with number of self-reported depressive episodes. Evidence is demonstrated for rumination being related to facets of mindfulness, whereby the four facets *'describe', 'act with awareness'*, '*non-judgement'* and *'non-reactivity'* were significantly negatively correlated with rumination. The partial hypothesis that rumination would be negatively related to greenspace and SED is rejected (see Table 4).

Table 4: Correlations

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Depression episodes	1															
2	Mindfulness practice	.27*	1														
3	FFMQ *Observe*	.19	.4	1													
4	FFMQ *Describe*	.01	.24*	.36*	1												
5	FFMQ *Act with Awareness*	-.16	.04	.14	.32*	1											
6	FFMQ *Non-judgement*	-.12	.15	.01	.21*	.37*	1										
7	FFMQ *Non-reactivity*	.01	.20	.39*	.33*	.34*	.32*	1									
8	FFMQ Total minus *Observe*	-.10	.21	.29*	.66*	.70*	.69*	.65*	1								
9	RRQ Rumination	.20	-.10	-.13	-.16	-.41*	-.58*	-.47*	-.58*	1							
10	RRQ Reflection	.13	.54*	.60*	.44*	.06	.04	.23	-.28*	-.05	1						
11	PTQ Total	.32*	.04	-.03	-.17*	-.50*	-.58*	-.42*	-.58*	.68*	.08	1					
12	250m % Greenspace	-.04	-.02	.15	.06	-.03	-.04	.13	-.01	-.05	.05	-.01	1				
13	250m % Public parks	-.02	-.09	-.10	.04	.02	-.12	-.07	-.03	-.05	-.18	-.01	.11	1			
14	3km % Greenspace	.02	.00	.11	.10	.07	.11	.01	.11	-.10	.03	-.03	.07	-.02	1		
15	3km % Public parks	.06	.03	.00	.02	.02	.15	-.04	.06	-.08	.05	-.06	.04	.88*	.67*	1	
16	Lower environmental deprivation	.06	.13	.12	.17	-.06	-.01	.12	.05	.01	.17	-.06	.30*	-.32*	-.29*	-.05	1

Note: *p=<0.001

Testing Hypothesis Two: Regression Analysis

Hierarchical multiple regression was carried out in four steps in order to test hypothesis two, that greenspace, SED, mindfulness facets and depression episodes would predict rumination when controlling for mindfulness practice and reflection. Table 5 details the results of the regression.

During correlational analysis, the PTQ was positively associated with the rumination subscale of the RRQ but not the reflection subscale. Reflection was positively associated with the 'describe' subscale of the FFMQ, as was mindfulness practice. Mindfulness practice was also positively associated with the reflection subscale of the RRQ (see table 4). Mindfulness practice was included in testing hypothesis two as a control variable, as it was associated with a facet of mindfulness, and may have influenced the model. Reflection was also a control variable, as it was related to both the '*describe*' subscale and mindfulness practice and may have influenced the model. Mindfulness practice and the reflection subscale of the RRQ were entered at step one as control variables, which did not statistically significantly explain the variance in rumination (F (2, 153) = 0.71, p = .50). Step two entered environmental measures, due to primary hypotheses (greenspace at 3km radii; public parkland at 3km radii, and relative environmental deprivation), and was also not statistically significant (F (5, 150) = 0.60, p = .70). Step three entered mindfulness measures, comprising FFMQ subscales: *describe*; *act with awareness*; *non-judgement of inner experience*; and *non-reactivity to inner experience*, due to previous research, current correlations, and current hypotheses. This model explained an additional 52.2% of the variance in rumination as measured by the PTQ, with the third stage explaining 54.1% (F (9, 146) = 19.15, p < .001). Finally, to satisfy hypotheses, step 4 entered recurrent depression frequency, which explained a further 2.2%, with the final model explaining 56.3% variance in rumination (F (10, 145)

= 18.70, $p < .001$). Proportionally within the final model, *non-judgement* explained roughly 45% variance in rumination ($p < .001$); *non-reactivity* explained around 18%, *act with awareness* explained around 29% and recurrent depression explained around 2% ($p < .05$).

Table 5: Hierarchical multiple regression results

	R Square	R Square change	B	*SE* B	ß
Step 1	.009	.009			
Constant	.		39.68	4.02	
Mindfulness practice			-0.45	0.78	-.54
Reflection			0.13	0.11	.11
Step 2	.020	.010			
Constant			37.43	5.15	
Greenspace 3km			0.12	0.11	.10
Parks 3km			-0.23	0.31	-.07
Environmental deprivation			-0.11	0.33	-.03
Step 3	.541**	.522**			
Constant			78.39	4.86	
Act with awareness			-0.64	0.13	-.32**
Non-reactivity			-0.42	0.15	-.18*
Non-judgement			-0.71	0.10	-.45**
Describe			-0.01	0.11	-.00
Step 4	.563*	.022*			
Constant			76.21	4.82	
Recurrent depression			0.51	0.19	.15*

Note: **p<.001; *p<.05

Testing hypothesis three: Moderation

To test hypothesis three, that recurrent depression would moderate the relationship between mindfulness facets and rumination, three moderation analyses were conducted. These were for each of the three facets of mindfulness that were significant in the regression model, namely non-judgement, act with awareness and non-reactively. In all

three models, number of depressive episodes was entered as the moderator variable, for the outcome variable of rumination. Model one used the *non-judgement* subscale as it was the strongest predictor of rumination in the regression analysis. Model two used the *act with awareness* subscale, and model three used *non-reactivity*. A dichotomous recurrent depression variable was used in the models, whereby past instances of depression were split into one to two times, and more than twice, due to group differences found in ruminative tendency in previous research (Radford et al., 2014). The null hypothesis for moderation was accepted for all three models.

Model one (N= 167) is conceptually summarised in Figure 4. *Non-judgement* and recurrent depression were mean-centred. The overall model predicted 45% variance in rumination (F (3, 163) = 45.26, p <.001, R^2 = .45). There was a significant direct effect of *non-judgement* on rumination (b_1 = -0.99, t (163) = -9.45, p <.001), in which non-judging of inner experience predicted less rumination. Recurrent depression significantly predicted increased rumination (b_2 = 4.94, t (163) = 3.85, p <.001). Those who had been depressed more than twice ruminated significantly more than those who had experienced depression once or twice. However, the interaction was insignificant (b = -0.23, t (163) = 1.10, p =.27) wherein moderation did not explain more of the variance in rumination (F (1, 163) = 1.22, p = .27). The relationship between *non-judgement* and rumination was significant and negative for both those who had been depressed once or twice (b = -1.09, t (163) = -7.34, p <.001) and for those who experienced recurrent depression (b = -0.86, t (163) = -6.00, p <.001).

Model two (N = 167) is conceptually summarised in Figure 5. The overall model significantly predicted 34% variance in rumination scores (F (3, 163) = 33.25, p <.001, R^2 = .34). Recurrent depression (b = 4.26, t (163) = 3.01, p =.003) significantly predicted higher rumination. *Acting with awareness* (b = -1.08, t (163) = -8.14, p <.001)

significantly predicted lower rumination, and the interaction was insignificant (b = 0.37, t (163) = 0.14, p = .89) wherein moderation did not additionally explain variance in rumination (F (1, 163) = 0.02, p = .89). The relationship between *acting with awareness* and rumination was significant for both those who had been depressed once or twice (b = -1.09, t (163) = -5.84, p <.001) and for those who experienced recurrent depression (b = -1.05, t (163) = -5.87, p <.001).

Model three (N = 167) is conceptually summarised in Figure 6. The overall model significantly predicted 23% variance in rumination scores (F (3, 163) = 20.35, p <.001, R^2 = .23). Recurrent depression (b = 6.08, t (163) = 4.23, p <.001) significantly predicted higher rumination. *Non-reactivity to inner experience* (b = -0.94, t (163) = -4.04, p <.001) significantly predicted lower rumination. There was no significant interaction effect (b = -0.52, t (163) = -1.19, p = .24) wherein moderation did not additionally explain variance in rumination (F (1, 163) = 1.42, p = .24). The relationship between *non-reactivity* and rumination was significant for both those who had been depressed once or twice (b = -0.73, t (163) = -2.00, p<.05) and for those who experienced recurrent depression (b = -1.24, t (163) = -5.30, p <.001).

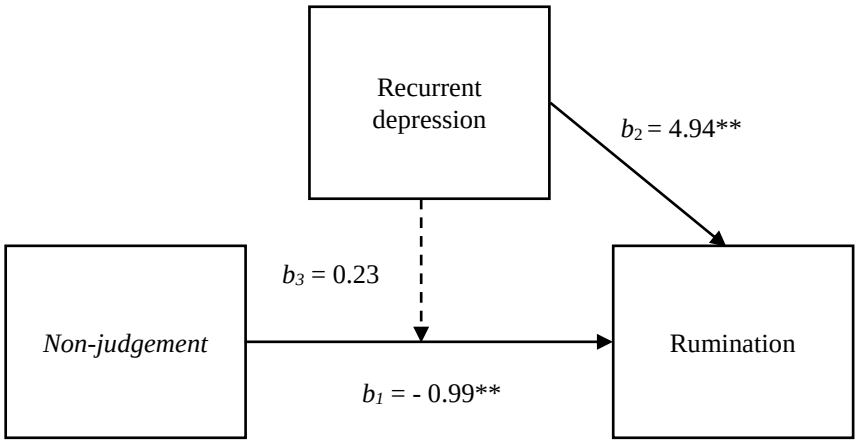

*Figure 4: Moderation model 1: Non-judgement. **p=<.001*

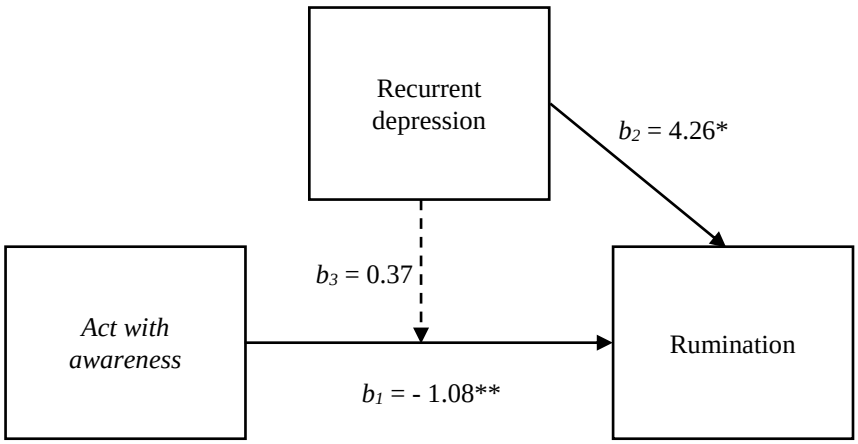

*Figure 5: Moderation model 2: Act with awareness. **p=<.001; *p=.003*

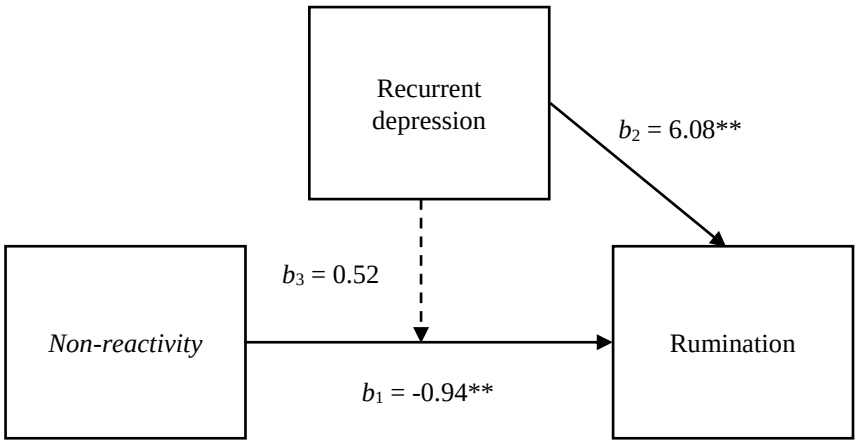

*Figure 6: Moderation model 3: Non-reactivity. **p=<.001*

Testing hypothesis four: Moderation

Hypothesis four was that there would be an indirect effect between greenspace and rumination, moderated by SED. The analysis investigated whether relative deprivation could be suppressing the effect of greenspace on rumination. The overall model was significant, F (3, 156) = 3.46, p< .05, explaining 8% variance in rumination. As indicated by previous correlations, both relative deprivation (b = -0.05, t(156) = -0.14, p = .89) and parkland density within 3km (b = -0.19, t(156) = -0.56, p = .58) did

not significantly predict rumination. However, a suppression effect of relative environmental deprivation on the association between parkland and rumination was evidenced in the significant interaction (b = 0.40, t(156) = 2.89, p<.005). Figure 7 summarises the conceptual model.

For those living in low deprivation areas, higher density parkland (b = -1.31, t(156) = -2.70, p<.01) predicted less rumination. For every percentage increase in parkland within 3km of residence, there was a decrease in rumination score by 1.31. For those living in areas of average deprivation relative to their country, parkland density (b = -0.19, t(156) = -0.56, p = .58) did not significantly predict rumination. For those living in areas of low deprivation relative to the rest of their country, the association between parkland and rumination did not reach significance (b = 0.93, t(156) = 1.72, p = .09).

However, the Johnson-Neyman technique suggested two zones of significance in opposite directions. For those living in areas from deciles one to three (most deprived), parkland negatively predicted rumination (t = -1.98, p = .05). From around decile eight and upward (least deprived), the association between parkland and rumination was positive (t = 1.98, p = .05). As environmental deprivation decreased, the effect of parkland on rumination changed direction from negative to positive. Figure 8 summarises the zones of significance. Model 4 confirmed hypothesis four via an indirect effect of SED on the relationship between parkland and rumination.

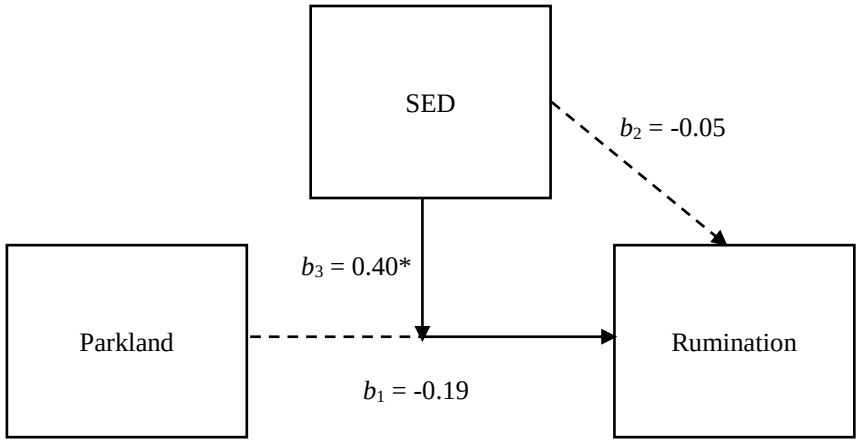

*Figure 7: Moderation model 4: Parkland; *p=<.005*

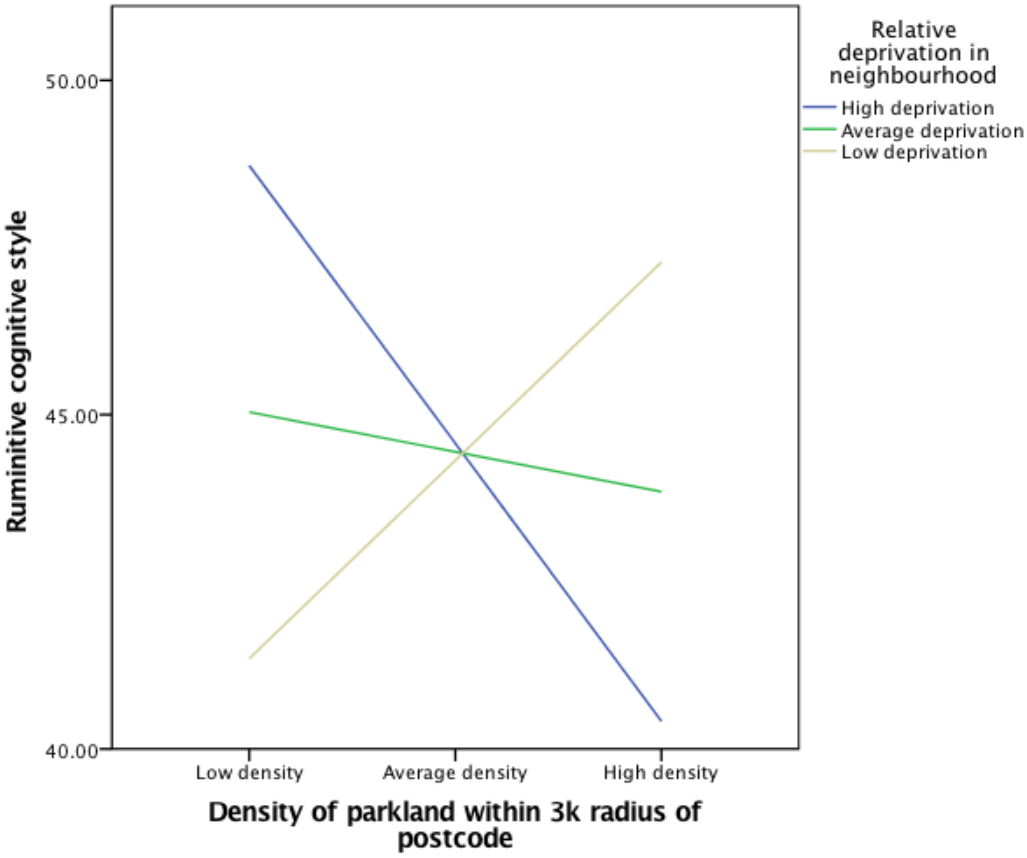

Figure 8: Summary of zones of significance

Discussion

The current study aimed to investigate the relationship between (1)

two aspects of neighbourhood environment (relative deprivation and greenspace), and 2) two cognitive mechanisms (facets of dispositional mindfulness and rumination) in people with self-reported recurrent depression. This objective was met. To date only two other studies have cross-sectionally investigated neighbourhood greenspace and depression in the UK (Cox et al., 2017; McEachan et al., 2015), and the current study is the first to investigate the relationship between rumination and neighbourhood greenspace in those who have experienced depression.

Rumination was measured in terms of the process of perseverative, ruminative thinking, using the PTQ. The PTQ was compared with a measure of rumination that differentiated between ruminative thoughts and reflective thoughts, and focused on content, the RRQ. This was done in order to ensure that a valid construct of rumination was being measured by the PTQ. The PTQ correlated with the rumination but not reflection subscale of the RRQ, so was accepted as a 'process' measure of rumination. Unlike previous studies, the current study recruited people who identified as not being currently depressed from a community sample to investigate the association between previous episodes of depression, rumination, and neighbourhood greenspace.

Summary: Hypothesis one

Hypothesis one was that rumination would be negatively related to greenspace and facets of mindfulness, and that rumination would be positively related with number of self-reported depressive episodes and relative environmental socioeconomic deprivation. Hypothesis one was partially confirmed, in that rumination and greenspace were negatively associated, but only for parkland within 3km of residence in aeas of high SED. Correlational analysis revealed no direct relationship between the psychological measures (rumination and mindfulness) and the environmental measures (SED and

greenspace). When neighbourhood SED was taken into account, the relationship between parkland and rumination became significant and more parkland within 3km of residence predicted less rumination for those whose neighbourhood fell within the first three (most deprived) deciles. The effect was not significant for those who lived in areas of moderate or low deprivation.

Hypothesis one was also confirmed in that rumination was negatively related to each of the four facets of dispositional mindfulness. However, rumination was not positively associated with relative environmental SED. Personal SED has been found to predict depression at both absolute and relative levels (Beshai et al. 2017; Kuo & Chiang, 2013). However, this study used indices of relative SED within neighbourhoods, and did not take affluence into account. An area with high deprivation may also contain high privilege, and the results of this study suggest that differences in deprivation between LSOAs may not be directly correlated with rumination or depression.

The association between parkland density and rumination may be explained within the context of ART, as natural environments such as greenspace are restorative of attention and cognitive capacity (Kaplan, 1995; Kaplan & Kaplan, 1989). Theoretically, greenspace meeting the requisite conditions for attention restoration could decrease attention fatigue, allowing focus on the present, external environment, reducing rumination.

Summary: Hypothesis two

Hypothesis two was that neighbourhood environment (including parks, aggregated greenspace, and SED), facets of mindfulness and self-reported number of depressive episodes would predict rumination, after controlling for mindfulness practice and reflection. Hypothesis two was partially confirmed, in that regression analysis

controlling for mindfulness practice and reflection confirmed that dispositional mindfulness powerfully predicted rumination, where adding mindfulness facets, excluding '*observe*' explained an additional 52% variance in rumination.

Non-judgement of inner experience was the most powerful negative predictor of ruminative tendency, accounting for 45% variance in rumination alone. This finding further supports longitudinal research suggesting that *non-judgement* may be the most powerful facet in protecting against rumination and depression over time (Petrocchi & Ottaviani, 2016). Hypothesis two was also partially confirmed in that regression showed that the number of depression episodes previously experienced predicted rumination, supporting previous findings (e.g. Radford et al., 2014). However, hypothesis two was partially rejected, as environmental greenspace, parks, and SED did not significantly predict rumination in the regression model. This was further investigated in moderation analysis for hypothesis four.

Summary: Hypothesis three

Hypothesis three was that recurrent depression would moderate the relationship between facets of mindfulness and rumination. Hypothesis three was rejected, as both those who had experienced depression once or twice, and those who had experienced it recurrently maintained the negative relationship between mindfulness and rumination with no significant difference between the groups for this association. This was true for each of the three significant mindfulness facets in the regression model, *'non-judgement'*, *'non-reactivity'*, and *'act with awareness'*.

Summary: Hypothesis four

Hypothesis four was that there would be an indirect effect, whereby SED moderated the relationship between greenspace and rumination. Hypothesis four was confirmed in moderation analysis. No direct relationship was evidenced between greenspace and rumination, which was consistent with correlation and regression analyses. However, a suppression effect of SED on the relationship between rumination and parkland was evidenced. For those living in high deprivation areas, higher density of parkland predicted less rumination, where for every percentage increase in parkland within 3km of residence, there was a decrease in rumination. No such association was found in the model for those living in areas with high or medium levels of deprivation. However, the Johnson-Neyman technique revealed two zones of significance in opposite directions. This meant that the negative relationship found between parkland and rumination for those living in areas of high deprivation was reversed and became a positive relationship, so that for those living in areas of low deprivation, higher density of parkland predicted more rumination It may be that publicly accessible urban parkland provides restoration and the ART concept of 'escape' in areas of high relative deprivation.

Limitations

Several elements of the design limited the current study. The cross-sectional design prevented causal inferences. Furthermore, the first primary hypothesis of the study concerned the relationship between environment and rumination, yet both environmental measures and previous episodes of depression were subject to single item measures in order to reduce participant burden. With regard to SED, the measure was sensitive only to deprivation within an area relative to the rest of the country, not to relative deprivation within area. For example, it may be that there is a relative deprivation effect within

LSOAs that have both high affluence and high deprivation that the study could not detect. Furthermore, recruitment limited the study to opportunity sampling as it was conducted online. It may have been a result of the social media driven advertising of the blog which advertised the study (particularly via Facebook and Twitter) that the majority of participants lived in urban environments. Additionally, while a wide range of charities and organisations were approached, including those focused on mental health and depression, it was largely mindfulness-focused groups and individuals who agreed to posting on their social media and 're-tweeting'. This may have been due to considerable demand already being placed on depression-focused social media for the purpose of recruitment to psychological studies concerning depression, as well as a greater perceived relevance of 'greenspace' or 'nature' for mindfulness-focused social media than for depression-focused social media.

Within ART, the quality of the experience of nature is salient to restorative effects (Kaplan, 1995). While this may go some way in explaining the prediction of rumination by urban parkland in deprived areas, the study failed to take subjective qualities into account. For example, the subjective quality of 'extent' could moderate the relationship between greenspace and rumination. Furthermore, 'compatibility' was not taken into account. It may be that a sense of nature-connectedness could impact the relationship between parkland and rumination, or that depression may be more predictable for particular levels of biophilic characteristics in the residents. The cross-sectional nature of the study prevents causal inferences, and so it may be that the link between urban parkland and rumination detected is circumstantial.

The 3km measure of greenspace may have provided a large enough circumference around postcode to be sensitive to parkland, which was a salient predictor. However, the 3km radii were also reliant on postcodes, which may not be accurate to

actual residence, decreasing the validity of the measure. It may be that use of an app or website linked with the study so that participants could have entered their postcodes and been able to see the circles would have allowed them to move them so that their home was the central point, and those data could have been recorded as a more accurate measure. This may be especially salient at the 250m radii.

A further limitation lies in the qualities measured. Greenspace was investigated as an indicator of urban nature, however, urban bluespace (water such as rivers, seafront, lakes, canals) was not included in the study. Highly accurate and specific measures of the numbers of trees are available, and could be calculated within small radii such as 250m, however, the study did not have sufficient funding to use such measures. A wider range of indicators of nature could allow for more meaningful aggregation into a nature measure. This would be more meaningful in examining these interactions within an ART framework. In addition, at analysis level, multiple non-parametric tests with Bonferroni correction may have resulted in type II errors, hiding possible small associations between environmental measures and rumination and depression.

Relationships found between mindfulness and rumination appear robust as predictions were strong and replicate previous research. However, it is possible that self-reported previous depression's association with rumination could be heightened by ruminative tendency, wherein rumination increases sensitivity to perceiving a greater number of past depressive episodes. Self-reported number of depressive episodes may be an inaccurate measure due to variability in memory and personal interpretation of each of the three items of inclusion for this measure. Furthermore, this study measured a 'currently well' sample, thus preventing determination of whether the interactions found may also differ during depression.

Clinical Implications

The current study suggests that urban parkland may be protective against rumination in areas of high deprivation. Causation cannot be inferred from this relationship, but may suggest potential benefit in psychologists taking environmental factors such as greenspace deprivation into account when collaboratively formulating with clients. As rumination was highly predictive of previous depressive relapse, the tentative suggestion can also be made that it is taken into account when formulating plans for relapse prevention following treatment for depression.

The negative prediction of rumination by the specific mindfulness facets of *non-judgement of inner experience, acting with awareness,* and *non-reactivity to inner experience* may imply that these could be powerful aspects of mindfulness for clinicians to focus their work on with clients who aim to reduce rumination. As previous research has demonstrated that rumination is a key factor in relapse into depression, provision of mindfulness training to strengthen these facets may be recommended. This is strengthened by the current finding that a greater number of depressive episodes was predictive of higher ruminative tendency. Relapse prevention work may benefit from augmentation with mindfulness techniques that encourage a more neutral, disinterested response to self-focused attention via these facets.

The current findings may have implications for specificity of mindfulness practice exercises in combination with previous research. The '*observe*' and '*describe*' facets have been found to slow performance in attentional tasks (Di Francesco et al., 2017). It may therefore be that exercises in observation could reverse the ruminative aspects and introduce enough neutrality to allow for soft fascination in favourable circumstances. It may also be that exercises that encourage the neutrality and psychological flexibility central to e.g. *non-judgement of inner experience* can have a

more direct effect on ruminative cognition, contributing to the ability to *act with awareness* (e.g. Malinowski, 2012; Petrocchi & Ottaviani, 2016). These results indicate that further exploration may be warranted, taking connection with nature into account. Participants who have recently experienced an episode of recurrent depression could potentially provide valuable data for longitudinal follow-up. Both number and timing of past episodes could be taken into account, as well as any events that may have instigated low mood, in exploring the roles of rumination and mindfulness in tendency to relapse.

Conclusions

The results of the study suggest that higher levels of dispositional mindfulness may be protective against rumination in people who have experienced depression. They also suggested that greenspace in the form of urban parkland within a 3km radius of residence may negatively predict rumination, but only for those living in areas of high deprivation. The results highlight the importance of taking a wide range of factors into account when investigating contributors to depression. Further research into associations between greenspace and rumination is warranted by this study's addition to a body of research investigating the impact of green in the neighbourhood as a psychological inequality. Further research is needed to investigate the positive relationship between rumination and parkland in areas with low levels of deprivation.

Longitudinal research may be particularly important in examining whether relapse into depression can be predicted by greenspace deprivation via rumination. Moreover, research should investigate whether *non-judgement, non-reactivity to inner experience*, and *acting with awareness* are protective against relapse, via reducing rumination in areas of high and low greenspace and SED. The burgeoning field of psycho-ecological research has produced mixed results between measuring greenspace to

differing levels of accuracy, distance and range from home, and by examining different types and combinations of greenspace (Cox et al., 2017).

Interactions found between parkland and socioeconomic deprivation in predicting rumination support the hypothesis that a complex constellation of environmental and cognitive factors may predict tendency to ruminate. The study also supports the hypothesis that ruminative tendency may predict relapse into depression. So far, the majority of investigation into greenspace and depression in community samples has focused on current symptoms. This study adds a perspective on ruminative tendency in using a process-driven rather than content-driven measure; and examining previous episodes of depression for people not currently depressed.

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Appendices

Appendix A: Author guidelines for publication in SAGE Open

Manuscript Preparation

Articles should not exceed 10,000 words (excluding references) and may present original research or literature reviews. The word count (which includes all text including the abstract, manuscript, notes, tables, figures, etc.) should appear on the title page. Manuscripts should include an abstract of approximately 150 words, and, beneath the abstract, 4-5 keywords. All manuscripts should follow the style guidelines set forth in the sixth edition of the *Publication Manual of the American Psychological Association*. Journal policy prohibits an author from submitting the same manuscript for consideration by another journal and does not allow publication of a manuscript that has been published in whole or in part by another journal.

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Appendix B: Literature Review Protocol

Title

The relationship between environmental greenspace and depression in adults: A systematic review and narrative synthesis

Type of Review

Systematic review

Inclusion Criteria

- Peer-reviewed research studies with non-experimental quantitative research designs
- Available in English
- Adult participants
- Research that uses reliable, peer reviewed depression measurement
- Research that measures outdoor greenspace in the residential environment

Exclusion Criteria

- Informal, non peer-reviewed research or quasi research
- Experimental, exclusively qualitative, or intervention studies, meta analyses
- Studies of non-humans, children, or young people that do not include adult participants as separately analysed
- Studies that do not measure depression (e.g. studies of the relationship between greenspace and physical health, mortality, or a measure of stress or wellbeing with no depression measure)
- Studies that do not measure residential greenspace (e.g. studies of indoor greenery in office spaces or virtual reality environments)

Search Strategy

Search Terms

- Depress* (to include iterations of depression); recurrent depress* (to include studies of depression that re-occurs); ruminat* (to include studies of rumination); perseverat* (to include studies of perseverative thinking, or rumination where it is conceptualised as perseveration): All combined with OR.
- Greenspace*; green space*; green-space (to return results about general greenspace); park; parkland; parks; wood*; ‘forest* (to return results about greenspace in the residential environment that may not specifically refer to it as such).

Databases

CORDIS; MEDLINE; PsycINFO; Science Direct; Scopus; Social Sciences Citation Index

Other Searches

Search reference lists of key texts, enquire regarding possible key tests missed with authors and experts.

Appendix C: Literature Search

Search ID#	Search Terms	Search Options	Actions
S15	S13 AND S14	**Search modes** - Find all my search terms	View Results (6,903)
S14	S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12	**Search modes** - Find all my search terms	View Results (80,028)
S13	S1 OR S2 OR S3 OR S4	**Search modes** - Find all my search terms	View Results (255,328)
S12	'forest*'	**Limiters** - Published: 19950101-20170431 **Search modes** - Boolean/Phrase	View Results (10,618)
S11	'wood*'	**Limiters** - Published: 19950101-20170431 **Search modes** - Boolean/Phrase	View Results (26,844)
S10	'parks'	**Limiters** - Published: 19950101-20170431 **Search modes** - Boolean/Phrase	View Results (43,803)
S9	'parkland'	**Limiters** - Published: 19950101-20170431 **Search modes** - Boolean/Phrase	View Results (136)
S8	'park'	**Limiters** - Published: 19950101-20170431 **Search modes** - Boolean/Phrase	View Results (43,803)
S7	'green-space'	**Limiters** - Published: 19950101-20170431 **Search modes** - Boolean/Phrase	View Results (202)
S6	'green space'	**Limiters** - Published: 19950101-20170431 **Search modes** - Boolean/Phrase	View Results (202)
S5	'greenspace'	**Limiters** - Published: 19950101-20170431 **Search modes** - Boolean/Phrase	View Results (32)
S4	'ruminat*'	**Limiters** - Published: 19950101-20170431 **Search modes** - Boolean/Phrase	View Results (4,769)
S3	'perseverat*'	**Limiters** - Published: 19950101-20170431 **Search modes** - Boolean/Phrase	View Results (2,669)
S2	'recurrent depress*'	**Limiters** - Published: 19950101-20170431 **Search modes** - Boolean/Phrase	View Results (1,505)
S1	'depress*'	**Limiters** - Published: 19950101-20170431 **Search modes** - Boolean/Phrase	View Results (251,065)

Appendix D: Quality Assessment: Newcastle-Ottawa Scale for Cohort Studies

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE
COHORT STUDIES

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability

Selection

1) Representativeness of the exposed cohort
   a) truly representative of the average _____ (describe) in the community ✵
   b) somewhat representative of the average _____ in the community ✵
   c) selected group of users eg nurses, volunteers
   d) no description of the derivation of the cohort

2) Selection of the non exposed cohort
   a) drawn from the same community as the exposed cohort ✵
   b) drawn from a different source
   c) no description of the derivation of the non exposed cohort

3) Ascertainment of exposure
   a) secure record (eg surgical records) ✵
   b) structured interview ✵
   c) written self report
   d) no description

4) Demonstration that outcome of interest was not present at start of study
   a) yes ✵
   b) no

Comparability

1) Comparability of cohorts on the basis of the design or analysis
   a) study controls for _____ (select the most important factor) ✵
   b) study controls for any additional factor ✵ (This criteria could be modified to indicate specific control for a second important factor.)

Outcome

1) Assessment of outcome
   a) independent blind assessment ✵
   b) record linkage ✵
   c) self report
   d) no description

2) Was follow-up long enough for outcomes to occur
   a) yes (select an adequate follow up period for outcome of interest) ✵
   b) no

3) Adequacy of follow up of cohorts
   a) complete follow up - all subjects accounted for ✵
   b) subjects lost to follow up unlikely to introduce bias - small number lost - > ____ % (select an adequate %) follow up, or description provided of those lost) ✵
   c) follow up rate < ____% (select an adequate %) and no description of those lost
   d) no statement

Appendix E: Quality Assessment: Adapted Newcastle-Ottawa Scale for Cross-sectional studies

NEWCASTLE-OTTAWA SCALE ADAPTED FOR CROSS-SECTIONAL STUDIES

Selection: (Maximum 5 stars)

1) Representativeness of the sample:
a) Truly representative of the average in the target population. * (all subjects or random sampling)
b) Somewhat representative of the average in the target population. * (non-random sampling)
c) Selected group of users.
d) No description of the sampling strategy.

2) Sample size:
a) Justified and satisfactory. *
b) Not justified.

3) Non-respondents:
a) Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory. *
b) The response rate is unsatisfactory, or the comparability between respondents and non-respondents is unsatisfactory.
c) No description of the response rate or the characteristics of the responders and the non-responders.

4) Ascertainment of the exposure (risk factor):
a) Validated measurement tool. **
b) Non-validated measurement tool, but the tool is available or described*
c) No description of the measurement tool.

Comparability: (Maximum 2 stars)

1) The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.
a) The study controls for the most important factor (select one). *
b) The study controls for any additional factor. *

Outcome: (Maximum 3 stars)

1) Assessment of the outcome:
a) Independent blind assessment. **
b) Record linkage. **
c) Self report. *
d) No description.

2) Statistical test:
a) The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (p value). *
b) The statistical test is not appropriate, not described or incomplete.

Appendix F: Quality Assessment: STROBE

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

Appendix G: Quality Assessment Tables

Study	STROBE Checklist Items continued											
	Results							Discussion				
	Participant numbers	Non-participation explained	Participant data	Descriptive data (missing)	Summary measures/outcome events	Unadjusted estimates, confounder adjusted	Any category boundaries and other analyses	Key results - references objectives	Limitations and bias discussed	Cautious overall interpretation	Generaliseability discussed	Source of funding stated
Akpinar et al, (2016)	★	-	-	-	★	★	★	★	★	★	-	-
Beyer, et al, (2014)	★	-	★	-	★	★	★	★	★	★	★	★
Bos, et al, (2016)	★	-	★	★	★	★	★	★	★	★	-	★
Cohen-Cline, et al, (2015)	-	-	★	-	★	-	★	★	★	★	★	★
Cox, et al, (2017)	-	-	★	-	★	★	★	★	★	★	★	★
McEachan et al, (2015)	★	-	★	★	★	★	★	★	★	★	★	★
Miles et al, (2011)	-	-	★	-	★	★	★	★	★	★	★	-
Min, et al, (2017)	-	-	★	-	★	★	★	-	★	★	★	★
Picavet et al, (2016)	-	-	★	★	★	-	★	-	★	★	-	★
Reklaitiene, et al (2014)	★	-	★	-	★	-	★	★	★	★	-	★
Song, et al (2007)	★	-	★	-	★	★	★	★	★	★	★	-

Study	STROBE Checklist Items continued											
	Results							Discussion				
	Participant numbers	Non-participation explained	Participant data	Descriptive data (missing)	Summary measures/outcome events	Unadjusted estimates, confounder adjusted	Any category boundaries and other analyses	Key results - references objectives	Limitations and bias discussed	Cautious overall interpretation	Generaliseability discussed	Source of funding stated
Akpinar et al, (2016)	★	-	-	-	★	★	★	★	★	★	-	-
Beyer, et al, (2014)	★	-	★	-	★	★	★	★	★	★	★	★
Bos, et al, (2016)	★	-	★	★	★	★	★	★	★	★	-	★
Cohen-Cline, et al, (2015)	-	-	★	-	★	-	★	★	★	★	★	★
Cox, et al, (2017)	-	-	★	-	★	★	★	★	★	★	★	★
McEachan et al, (2015)	★	-	★	★	★	★	★	★	★	★	★	★
Miles et al, (2011)	-	-	★	-	★	★	★	★	★	★	★	-
Min, et al, (2017)	-	-	★	-	★	★	★	-	★	★	★	★
Picavet et al, (2016)	-	-	★	★	★	-	★	-	★	★	-	★
Reklaitiene, et al (2014)	★	-	★	-	★	-	★	★	★	★	-	★
Song, et al (2007)	★	-	★	-	★	★	★	★	★	★	★	-

Study	Newcastle-Ottawa Scale for the Cohort Study								
	Representative exposed cohort (/★)	Selection of non-exposed cohort (/★)	Ascertainment of exposure (/★)	Outcome of interest was not present at start of study (/★)	Comparability of cohorts (/★★)	Assessment of outcome (/★)	Adequate follow-up time (/★)	Adequate follow-up detail (/★)	Total methodology star rating (/9)
Picavet et al, (2016)	-	-	★	(Difference shown) ★	★	-	★	(description provided) ★	5
Study	**Newcastle-Ottawa scale for Cross-sectional studies**								
	Representative sample (/★)	Justified sample size (/★)	Described/Justified response rate (/★)	Validated measurement tools (greenspace) (/★★)	Controlled confounders (/★★)	Assessment of outcome (depression) (/★★)	Appropriate statistical test and reporting (/★)	Total methodology star rating (/10)	Ranking of cross-sectional study methodology
Akpinar et al, (2016)	★	★	-	★	★★	★	★	7	3
Beyer, et al, (2014)	★	★	★	★★	★★	★	★	9	1
Bos, et al, (2016)	★	★	★	★★	★★	★	★	9	1
Cohen-Cline, et al, (2015)	★	★	-	★★	★★	★	★	8	2
Cox, et al (2017)	★	★	-	★★	★★	★	★	8	2
McEachan et al, (2015)	★	★	★	★★	★★	★	★	9	1
Miles et al, (2011)	★	★	-	★	★	★	★	6	4
Min, et al, (2017)	★	★	-	★	★★	★	★	7	3
Reklaitiene, et al (2014)	★	★	★	★	★★	★	★	8	2
Song et al, (2007)	★	★	★	★	★★	★	★	8	2

Appendix H: DClinPsy Research Review Committee Approval

UNIVERSITY OF LIVERPOOL

D.Clin.Psychology Programme
Division of Clinical Psychology
Whelan Building, Quadrangle
Brownlow Hill
LIVERPOOL
L69 3GB

Tel: 0151 794 5530/5534/5877
Fax: 0151 794 5537
www.liv.ac.uk/dclinpsychol

7th August, 2015

Adele Hurst
Clinical Psychology Trainee
Doctorate of Clinical Psychology Doctorate Programme
University of Liverpool
L69 3GB

RE: *'Dispositional mindfulness, socioeconomic deprivation, urbanicity, green space and recurrent depression: A mediation and moderation analysis'*

Trainee: Adele Hurst

Supervisors: Catrin Eames & Peter Malinowski

Dear Adele,

Thank you for submitting your revised research proposal to the DClinPsychol Research Committee and accompanying letter to the Chair.

I can now confirm that your proposal (*version 2; 20/07/2015*) and your original research budget (June, 2015) meet the requirements of the committee and have been approved on Chair's Action.

Please take this decision as ***final*** approval from the committee.

You may now progress to the next stages of your research.

I wish you well with your research project.

Dr Joanne Dickson

Appendix I: University Ethical Approval Letter

Health and Life Sciences Committee on Research Ethics (Psychology, Health and Society)

15 June 2016

Dear Dr Eames,

I am pleased to inform you that your application for research ethics approval has been approved. Details and conditions of the approval can be found below:

Reference:	0392
Project Title:	Mindfulness, thinking, and environments
Principal Investigator:	Dr Catrin Eames
Co-Investigator(s):	Miss Emilia Trapasso, Dr Rebecca Lawson
Student Investigator(s):	-
Department:	
Reviewer:	Dr Charlotte Hardman, Dr Judi Smith
Approval Date:	15/06/2016
Approval Expiry Date:	30/09/2017

The application was APPROVED subject to the following conditions:

Conditions

- All serious adverse events must be reported to the Subcommittee within 24 hours of their occurrence, via the Research Integrity and Ethics Officer (ethics@liv.ac.uk).
- If it is proposed to extend the duration of the study beyond the expiry date listed above, the Subcommittee should be notified.
- If it is proposed to make an amendment to the research, you should notify the Subcommittee by following the Notice of Amendment procedure.
- If the named Principal Investigator or Supervisor leaves the employment of the University during the course of this approval, the approval will lapse. Therefore please contact the Committee (details below) in order to notify them of a change in Principal Investigator or Supervisor.

Kind regards,

Health and Life Sciences Committee on Research Ethics (Psychology, Health and Society)
iphsrec@liverpool.ac.uk
0151 794 5799

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Appendix J: Participant Information

Mindfulness, thinking, and environments

Participant Information

Institute of Psychology, Health and Society,
University of Liverpool
Waterhouse Building, Block B,
Brownlow Street,
Liverpool
L69 3GL

Principal Investigator:
Dr Catrin Eames: Catrin.eames@liverpool.ac.uk
Co-Investigator:
Dr Peter Malinowski: P.Malinowski@ljmu.ac.uk
Student Researchers:
Adele Hurst: adeleh@liverpool.ac.uk
Emilia Trapasso: E.Trapasso@liverpool.ac.uk

Research ethics number: 0392

You are being invited to participate in a research study. Before you decide whether to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and feel free to ask us if you would like more information or if there is anything that you do not understand. Please also feel free to discuss this with your friends, relatives and your GP if you wish. Take time to decide whether or not you wish to take part. We would like to stress that you do not have to accept this invitation and should only agree to take part if you want to. Thank you for reading this.

What is the purpose of this study?
We are looking at how the environment we live in can affect our mental health and wellbeing, for example our proximity and connection to nature and green space, and how this can affect how we perceive and experience stress. Previous research has shown that those who live close to green space have better mental health than those who are from an urban area. We want to better understand this relationship between our everyday environment and thinking styles like worrying a lot, or thinking about the past a lot. There has been other research that has shown that people who live in areas where there is deprivation, including things like poverty and lack of access to services, suffer more from depression. It has also been shown that there might be a relationship between living near natural environments, or very urban environments without much natural green space, and mental health outcomes like depression.

As well as environment, thinking styles like worrying and thinking about the past have been linked with becoming depressed more than once. Mindfulness is a way of thinking and being, where you pay attention to the current moment on purpose and without judging or overthinking it. It is almost an opposite of worrying and thinking about the past a lot. Mindfulness therapies have helped people who have become depressed lots of times in the past.

We want to look at these things together to see what the relationships are. We want to see whether there is a link between environmental factors like deprivation and green space, and worrying and thinking about the past. We want to see if mindfulness changes that relationship. We are especially interested whether mindfulness is related to that relationship differently for people who have been depressed many times in the past.

Who can take part?

People aged 18 or over who live in England or Wales and are not currently depressed can take part. If you are under 18, don't live in England or Wales, or if you are currently depressed we can't use your information. This is because we have to look at a specific group of people for research purposes. Things can be quite different for adults and young people, we are comparing data using measures from England and Wales, and we are looking at things that current depression could alter and invalidate our results.

Do I have to take part?
No. Participation is voluntary so you do not have to take part. If you do take part, you will be asked to select boxes consenting (agreeing) that you understand this and that you really do want to take part. If you change your mind part way through you can close the browser window. You don't have to give a reason or incur a disadvantage for not taking part.

What will happen if I take part?
If you decide to help us in this study, you will be asked to complete a set of questionnaires honestly in an online survey. You don't have to write anything, it is all box-ticking. Everybody goes at a different pace, you are not being timed, and there are no wrong answers. We think that it will take about 30 minutes to complete. The researchers will look at all of the information that people give us on the survey and work out whether there are any links between the things we are researching. We will write this up in a report, but all identities will be kept anonymous, and won't be written about individually. You can have a copy of the final report if you wish.

Are there any risks in taking part?
There are no significant risks in taking part, as the study is online and not in person. However, it does ask about depression and thinking, and if you feel upset by this you do not have to continue, and you can withdraw from the study at any time. You can access information on sources of support at the end of the study, or on the research blog.

What are the possible benefits of taking part?
You will not directly benefit from participation in this study. If you take part you will be helping us with trying to find answers by researching this subject. As a thank you for taking part in the study we are offering the chance to enter a prize draw for one of thirteen gift vouchers (two £50 vouchers, six £25 vouchers and five £10 vouchers). Details will be given at the end of the study.

Will my participation be kept confidential?
Yes. Your anonymous data will be kept securely in electronic form by the data custodian, Catrin Eames, until September 2022, when it will be deleted.

What if I am unhappy or there is a problem?
If you are unhappy, or if there is a problem, please feel free to let us know by contacting the Principle Investigator, Dr Catrin Eames (0151 7945530; catrin.eames@liverpool.ac.uk) and we will try to help. If you remain unhappy or have a complaint which you feel you cannot come to us with then you should contact the Research Governance Officer at ethics@liv.ac.uk. When contacting the Research Governance Officer, please provide details of the name or description of the study (so that it can be identified), the researcher(s) involved, and the details of the complaint you wish to make.

What will happen to the results?
Once the study is complete we will analyse the results and try to have them published in academic journals. We will not identify you in any way when the results are published. We will let people know what is happening on the research blog. We will send you a copy of any reports if you wish.

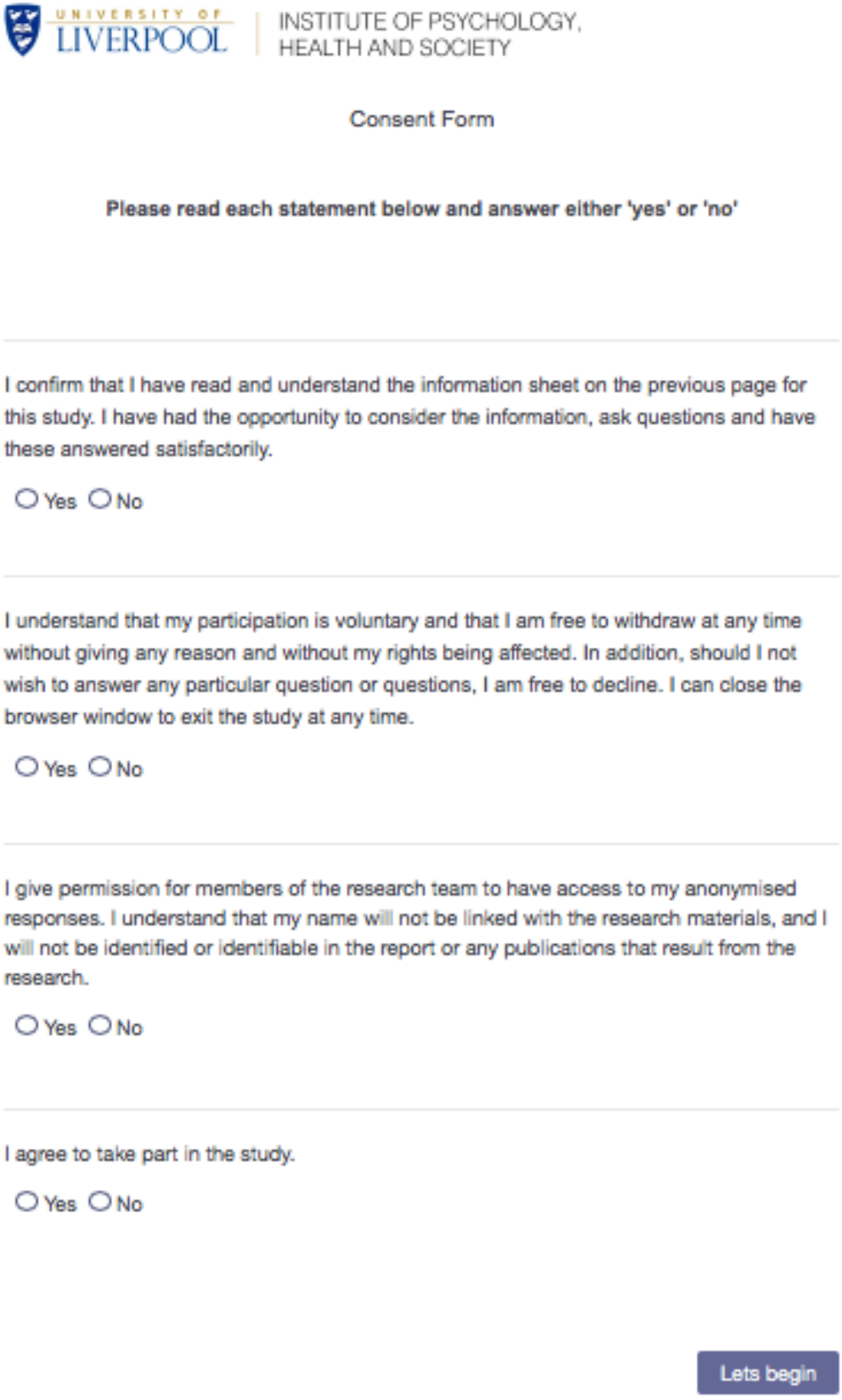
What will happen if I want to stop taking part?
You are free to withdraw at any time without giving a reason and without incurring a disadvantage. You can close the window with the survey and you do not have to do it again.

What if I want to ask questions not included in this information?

Please raise any further questions you may have with the researchers on this study who will be happy to answer you. You can email adele.hurst@liverpool.ac.uk or e.trapasso@liverpool.ac.uk. Alternatively please feel free to contact the Principal Investigator: Dr Catrin Eames, on 0151 794 5530 (catrin.eames@liverpool.ac.uk) or the Co-Investigator: Dr Peter Malinowski, on 0151 904 6297 (p.malinowski@ljmu.ac.uk).

Can you give me advice on depression?
We cannot give you any specific advice on depression, but we provide some details of places where you can seek information and support at the end of the study and on the research blog.

Appendix K: Consent Form



UNIVERSITY OF LIVERPOOL | INSTITUTE OF PSYCHOLOGY, HEALTH AND SOCIETY

Consent Form

Please read each statement below and answer either 'yes' or 'no'

I confirm that I have read and understand the information sheet on the previous page for this study. I have had the opportunity to consider the information, ask questions and have these answered satisfactorily.

○ Yes ○ No

I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without my rights being affected. In addition, should I not wish to answer any particular question or questions, I am free to decline. I can close the browser window to exit the study at any time.

○ Yes ○ No

I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or any publications that result from the research.

○ Yes ○ No

I agree to take part in the study.

○ Yes ○ No

Lets begin

Appendix L: Rumination-Reflection Questionnaire (Trapnell & Campbell, 1999)

RRQ

Instructions:

For each of the statements located on the next two pages, please indicate your level of agreement or disagreement by circling one of the scale categories to the right of each statement. Use the scale as shown below:

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

1.	My attention is often focused on aspects of myself I wish I'd stop thinking about.	1	2	3	4	5
2.	I always seem to be "re-hashing" in my mind recent things I've said or done.	1	2	3	4	5
3.	Sometimes it is hard for me to shut off thoughts about myself.	1	2	3	4	5
4.	Long after an argument or disagreement is over with, my thoughts keep going back to what happened.	1	2	3	4	5
5.	I tend to "ruminate" or dwell over things that happen to me for a really long time afterward.	1	2	3	4	5
6.	I don't waste time re-thinking things that are over and done with.	1	2	3	4	5
7.	Often I'm playing back over in my mind how I acted in a past situation.	1	2	3	4	5
8.	I often find myself re-evaluating something I've done.	1	2	3	4	5
9.	I never ruminate or dwell on myself for very long.	1	2	3	4	5
10.	It is easy for me to put unwanted thoughts out of my mind.	1	2	3	4	5
11.	I often reflect on episodes in my life that I should no longer concern myself with.	1	2	3	4	5
12.	I spend a great deal of time thinking back over my embarrassing or disappointing moments.	1	2	3	4	5
13.	Philosophical or abstract thinking doesn't appeal to me that much.	1	2	3	4	5
14.	I'm not really a meditative type of person.	1	2	3	4	5
15.	I love exploring my "inner" self.	1	2	3	4	5
16.	My attitudes and feelings about things fascinate me.	1	2	3	4	5
17.	I don't really care for introspective or self-reflective thinking.	1	2	3	4	5
18.	I love analyzing why I do things.	1	2	3	4	5
19.	People often say I'm a "deep", introspective type of person.	1	2	3	4	5
20.	I don't care much for self-analysis.	1	2	3	4	5
21.	I'm very self-inquisitive by nature.	1	2	3	4	5
22.	I love to meditate on the nature and meaning of things.	1	2	3	4	5
23.	I often love to look at my life in philosophical ways.	1	2	3	4	5
24.	Contemplating myself isn't my idea of fun.	1	2	3	4	5

Appendix M: Perseverative Thinking Questionnaire (Ehring et al., 2011)

In the next questions, you will be asked to think about how you *typically* think about negative experiences or problems. Please read the following statements and rate the extent to which they apply to you when you think about negative experiences or problems.

	Never	Rarely	Sometimes	Often	Almost always
The same thoughts keep going through my mind again and again.	○	○	○	○	○
Thoughts intrude into my mind.	○	○	○	○	○
I can't stop dwelling on them.	○	○	○	○	○
I think about many problems without solving any of them.	○	○	○	○	○
I can't do anything else while thinking about my problems.	○	○	○	○	○
My thoughts repeat themselves.	○	○	○	○	○
Thoughts come to my mind without me wanting them to.	○	○	○	○	○
I get stuck on certain issues and can't move on.	○	○	○	○	○
I keep asking myself questions without finding an answer.	○	○	○	○	○
My thoughts prevent me from focusing on other things.	○	○	○	○	○
I keep thinking about the same issue all the time.	○	○	○	○	○
Thoughts just pop into my mind.	○	○	○	○	○
I feel driven to continue dwelling on the same issue.	○	○	○	○	○
My thoughts are not much help to me.	○	○	○	○	○
My thoughts take up all my attention.	○	○	○	○	○

Appendix N: Five Facet Mindfulness Questionnaire (FFMQ: Baer et al., 2008)

Five Facet Mindfulness Questionnaire

Description:

This instrument is based on a factor analytic study of five independently developed mindfulness questionnaires. The analysis yielded five factors that appear to represent elements of mindfulness as it is currently conceptualized. The five facets are observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience. More information is available in:

Please rate each of the following statements using the scale provided. Write the number in the blank that best describes your own opinion of what is generally true for you.

1	2	3	4	5
never or very rarely true	rarely true	sometimes true	often true	very often or always true

_____ 1. When I'm walking, I deliberately notice the sensations of my body moving.
_____ 2. I'm good at finding words to describe my feelings.
_____ 3. I criticize myself for having irrational or inappropriate emotions.
_____ 4. I perceive my feelings and emotions without having to react to them.
_____ 5. When I do things, my mind wanders off and I'm easily distracted.
_____ 6. When I take a shower or bath, I stay alert to the sensations of water on my body.
_____ 7. I can easily put my beliefs, opinions, and expectations into words.
_____ 8. I don't pay attention to what I'm doing because I'm daydreaming, worrying, or otherwise distracted.
_____ 9. I watch my feelings without getting lost in them.
_____ 10. I tell myself I shouldn't be feeling the way I'm feeling.
_____ 11. I notice how foods and drinks affect my thoughts, bodily sensations, and emotions.
_____ 12. It's hard for me to find the words to describe what I'm thinking.
_____ 13. I am easily distracted.
_____ 14. I believe some of my thoughts are abnormal or bad and I shouldn't think that way.

_____ 15. I pay attention to sensations, such as the wind in my hair or sun on my face.
_____ 16. I have trouble thinking of the right words to express how I feel about things
_____ 17. I make judgments about whether my thoughts are good or bad.
_____ 18. I find it difficult to stay focused on what's happening in the present.
_____ 19. When I have distressing thoughts or images, I "step back" and am aware of the thought or image without getting taken over by it.
_____ 20. I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing.
_____ 21. In difficult situations, I can pause without immediately reacting.
_____ 22. When I have a sensation in my body, it's difficult for me to describe it because I can't find the right words.
_____ 23. It seems I am "running on automatic" without much awareness of what I'm doing.
_____24. When I have distressing thoughts or images, I feel calm soon after.
_____ 25. I tell myself that I shouldn't be thinking the way I'm thinking.
_____ 26. I notice the smells and aromas of things.
_____ 27. Even when I'm feeling terribly upset, I can find a way to put it into words.
_____ 28. I rush through activities without being really attentive to them.
_____ 29. When I have distressing thoughts or images I am able just to notice them without reacting.
_____ 30. I think some of my emotions are bad or inappropriate and I shouldn't feel them.
_____ 31. I notice visual elements in art or nature, such as colors, shapes, textures, or patterns of light and shadow.
_____ 32. My natural tendency is to put my experiences into words.
_____ 33. When I have distressing thoughts or images, I just notice them and let them go.
_____ 34. I do jobs or tasks automatically without being aware of what I'm doing.
_____ 35. When I have distressing thoughts or images, I judge myself as good or bad, depending what the thought/image is about.
_____ 36. I pay attention to how my emotions affect my thoughts and behavior.
_____ 37. I can usually describe how I feel at the moment in considerable detail.
_____ 38. I find myself doing things without paying attention.
_____ 39. I disapprove of myself when I have irrational ideas.

Appendix O: Comparison of groups

Mann-Whitney U testing, and independent t-tests were conducted to investigate gender and country differences following homogeneity testing. Results are summarised in the following table.

'Appendix O' Table: Comparison of groups

Variable	Groups		Comparison
Country	**England**	**Wales**	
Urban density[1]	*Md* = 72, *n* = 155	*Md* = 39, *n* = 29	*U* = 1050, *z* = -.46, *p* < .001, *r* = -.003*
Parkland density[1]	*Md* = 2.68, *n* = 146	*Md* = .65, *n* = 24	*U* = 589, *z* = -5.21, *p* < .001, *r* = -.40*
SED	*Md* = 5.00, *n* = 158	*Md* = 4.00, *n* = 30	*U* = 2146, *z* = -.83, *p* = .41, *r* = -.06
RRQ Reflection	*M* = 3.35, *SD* = 0.76	*M* = 3.41, *SD* = 0.65	*t* (178) = -.45, *p* = .65, two-tailed
Gender	**Females**	**Males**	
Parkland density[1]	*Md* =2.22, *n* = 143	*Md* = 1.11, *n* = 27	*U* = 1841, *z* = -.38, *p* = .70, *r* = -.03
Past depression	*Md* =2.00, *n* = 161	*Md* = 2.00, *n* = 33	*U* = 2883, *z* = .80, *p* = .43, *r* = .06
FFMQ *Observe*	*M* = 26.46, *SD* = 5.69	*M* = 26.73, *SD* = 4.70	*t* (172) = -.23, *p* = .82, two-tailed
FFMQ *Describe*	*M* = 27.40, *SD* = 6.08	*M* = 25.38, *SD* = 7.53	*t* (172) = 1.5, *p* = .14, two-tailed

Note: *Significant difference, adjusted by Bonferroni correction (*p* < .006), in which 0.05 is divided by eight comparisons listed above; [1]3km radii

There were significant differences between England and Wales for parkland within 3km radii, with a medium effect size, and for urban territory percentage within 3km radii, with a small effect size.

A two-way between-groups analysis of variance was conducted to investigate the impact of gender and country on rumination as measured by the PTQ. The interaction effect between gender and country was not significant, F (1, 175) = .115, p = .74. There was a statistically significant main effect for country, F (1, 175) = 5.19, p = .02, however, the effect size was small (partial eta squared = .03). The main effect for gender did not reach significance, F (1, 175) = .143, p = .24.